Dechlorane plus in in- and outdoor air of an urban city in Southern China

Ren GF[1,2], Yu ZQ[1], Ma ST[1], Chen LG[1], Luo XF[2], Sheng GY[1], Fu JM[1,2]

[1]Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China

[2]Shanghai University, Shanghai, China

Abstract.

Dechlorane Plus (DP), a highly chlorinated flame retardant, was measured in air in 14 homes, 6 offices, and 10 public microenvironments from Guangzhou and compared to Spatially and temporally consistent outdoor levels. DP was detected in all of the air samples. As a whole, arithmetic mean and median DP air concentrations in indoor are 24.00±52.27 and 9.84pg/m^3, respectively. The arithmetic mean and median concentrations of DP in outdoor air are 36.00±31.67 and 28.76pg/m^3, respectively. Average *anti*-DP fractional abundance (f_{anti}= 0.65±0.04) in all outdoor samples was similar to those reported in other studies and indistinguishable from that of the commercial mixture (f_{anti}= 0.65). In contrast, a relatively large f_{anti} value variation was found in the indoor samples, suggesting a complex degradation process of DP existing in these microenvironment. Based on the calculated DP concentrations in indoor and outdoor air from South China, the daily inhalation rate of DP was estimated. This limited dataset indicates that daily mean background intake DP via inhalation to be 0.29ng day^{-1} with a range of 0.038-2.21ng day^{-1}for a typical person.

Introduction.

Dechlorane Plus (DP), is a kind of unregulated chlorinated flame retardant , which was introduced into the market in 1960 to replace the toxic Dechlorane or Mirex[1]. As the flame retardant, commercial DP mixture is added primarily in industrial polymers used for coating electrical wires and cables, connectors used in computers, and plastic roofing material[2]. Few data on physical and chemical properties are available for DP, except an environmental test plan for DP generated by OxyChem in 2005. According to this plan, DP has the typical characteristics of a persistent organic pollutant: high lipophlicity, resistance to photo- and biodegradation, and accumulation in fish[1]. This was proved by a series of recent reports. DP has been detected in a wide range of abiotic and biotic samples from North America, Europe, and Asia[3-6]. Our recent study also demonstrates that DP can bioaccumulated in the human body and undergone possible dechloranated metabolation[7]. In this study， we determined the DP concentrations in air samples taken from a variety of buildings, and compared them with those present in ambient outdoor air, and assessed the potential significance of inhalation as a pathway of human exposure to DP.

Materials and methods.

14 homes and 16 workplaces [including 6 offices and 10 other indoor microenvironments] located in Guangzhou and Foshan cities were selected for indoor air sampling between October 2004 and April 2005. For nine indoor locations, spatially and temporally consistent outdoor air samples were collected .PUF plugs and QFFs were Soxhlet extracted with acetone:hexane mixture (1:1)and then cleaned and fractionated on acid/basic multilayer silica gel columns. The final extracts were concentrated to 200μL and then analyzed by an Agilent 7890 series gas chromatograph coupled to an Agilent 5975C mass spectrometer (GC/MS). A 15m DB-5-HT MS column (250 um i.d; 0.25 um film thickness; J&W Scientific, Folsom, CA) was used for the DP analysis.

Table1. Summary of DP levels (pg/m^3) in indoor (a) and outdoor (b) air samples

	Workplace											
	Office(n=6)						Other microenvironment(n=10)					
	Min	Max	Median	Mean	S.D.	Geo-mean	Min	Max	Median	Mean	S.D.	Geo-mean
(a) indoor air												
s-DP	0.93	6.25	1.54	2.29	1.98	1.84	1.87	140.06	8.95	24.08	42.35	9.75
a-DP	1.08	10.10	2.20	3.44	3.36	2.57	6.61	144.41	23.32	33.19	40.85	21.53
∑DP	2.49	16.35	3.62	5.73	5.33	4.46	10.16	284.46	32.58	57.27	83.08	32.08

	Home(n=14)						Outdoor(n=8)					
	Min	Max	Median	Mean	S.D.	Geo-mean	Min	Max	Median	Mean	S.D.	Geo-mean
	(a) indoor air						(b) outdoor air					
s-DP	0.53	8.82	3.82	4.13	2.90	3.01	2.34	30.82	9.30	12.05	10.49	8.39
a-DP	0.86	10.67	3.80	3.95	2.60	3.26	4.08	58.60	19.46	23.94	21.21	16.10
∑DP	1.40	19.49	6.87	8.08	5.17	6.48	7.09	89.42	28.76	36.00	31.67	24.56

	All indoor (n=30)					
	Min	Max	Median	Mean	S.D.	Geo-mean
(a) indoor air						
s-DP	0.53	140.06	4.08	10.41	25.66	4.04
a-DP	0.86	144.41	4.19	13.60	26.86	5.84
∑DP	1.40	284.46	9.84	24.00	52.27	10.25

Results and Discussion

DP concentration in air from different categories of indoor and outdoor. As shown in Table 1, DP was detected in all the air samples, the average (median) values of atmospheric ΣDP concentrations in the three indoor microenvironment are 5.73±5.33 (3.62), 8.08±5.17 (6.87) and 57.27±83.08 (32.58) pg/m^3 for office, home, and other microenvironment, respectively. As a whole, arithmetic mean and median DP air concentrations in indoor are 24.00±52.27 and 9.84pg/m^3, respectively. The DP concentrations in other microenvironment were significantly higher than those in home and office, suggesting that more likely source of DP located in those microenvironments. The arithmetic mean and median concentrations of DP in outdoor air are 36.00±31.67 and 28.76pg/m^3, respectively. In summary, the mean value of DP concentration in outdoor are slightly higher than those for indoor air, but without a clear cut indoor－outdoor gradient.

DP Stereoisomer Profile. Technical DP has two conformational isomers: *syn*(u shaped) and *anti*(chair shaped). Stereoisomers could have different physical and chemical properties leading to variation in their persistence in the environment. In this study，the stereoisomer profiles and fractional abundance (f_{anti}: as defined as the concentration of the *anti*-isomer divided by the sum of the concentrations of *syn*- and *anti*-isomers) in our air samples are shown in Figure1. Mean f_{anti} in all outdoor samples was 0.65±0.04, value indistinguishable from that of a commercial mixture. Previous study had demonstrated relatively constant f_{anti} values in the ambient air measurements in the Great Lakes. A recent study of airborne DP across 97 Chinese urban and rural areas found mean f_{anti} values of 0.68 and 0.66, respectively, which were similar to those measured in outdoor air samples in this study. In contrast, the mean f_{anti} in all indoor samples was 0.59±0.13, value with a great variation. The large variation of this value in indoor air samples suggests a complex degradation process of DP in some microenvironments.

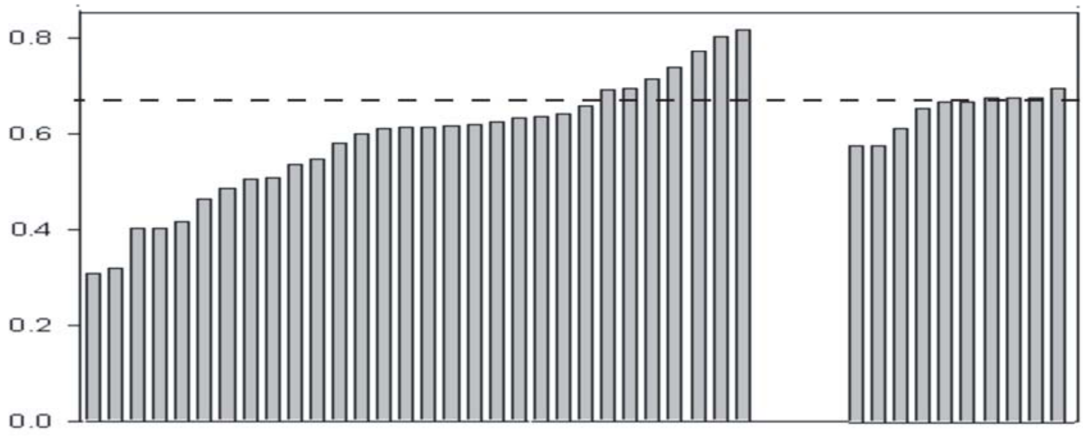

Figure1. The f_{anti} values for all indoor and outdoor air samples. plotted in order of increasing f_{anti} value. The broken line indicates the value of commercial product(f_{anti}=0.65).

Exposure to DP via air inhalation. The presence of DP in indoor and outdoor environments could have implications for potential human exposure to this chemical. Using the data reported here, we have estimated the likely range and arithmetic mean of human intake of DP via inhalation. Daily human exposure to DP falls within the range of 0.038-2.21ng day^{-1}, with a mean of 0.29ng day^{-1} for a typical person. Table 2 summarizes estimates of the range, mean, and median values of DP and

BDE-209 from our previous study. The calculated DP inhalation intake is much lower than those obtained in our previous study for the intake of BDE-209[8]. Zhu et al. estimated the exposure of adults to DP via dust ingestion in the city of Ottawa, Canada[9]. Comparison of our median daily human exposure to DP with zhu's, dust ingestion and air inhalation contributed equal magnitude of total DP exposure, indicating that exposure through air inhalation may be another important pathway for the background person.

Table2 calculated human exposure(ngday^{-1}person^{-1}) to DP through inhalation or ingestion

	This study(through inhalation)				Zhu's study(through ingestion)			
	Min	Max	Median	Mean	Min	Max	Median	Mean
s-DP	0.014	1.05	0.061	0.131				
a-DP	0.023	1.17	0.103	0.164				
∑DP	0.038	2.21	0.162	0.290		24	0.06	0.46

Acknowledgments—This study was financially supported by the Chinese Academy of Sciences (KZCX2-YW-403), the National Basic Research Program of China (2008CB418205), the National Science Foundation of China (40590392, 40873075), the Earmarked Fund of the State Key Laboratory of Organic Geochemistry (SKLOG2008A03). This is contribution No. IS- 1129 from GIGCAS.

References :

1 Occidental Chemical Corporation (OxyChem), Dechlorane Plus (DP) Manual. *http://www.oxy.com/OXYCHEM/Products/dechlorane-plus/dechlorane-plus.htm.*

2 High Production Volume (HPV) Challenge. *http://www.epa.gov/chemrtk/pubs/summaries/dechlorp/c15635tc.htm.*

3 Hoh, E.; Zhu, L.; Hites, R. A., *Environ. Sci. Technol.*(2006), 40, 1184-1189.

4 Gauthier, L. T.; Hebert, C. E.; Weseloh, D. V. C.; Letcher, R. J., *Environ. Sci. Technol*. (2007), 41, 4561-4567.

5 Qiu, X.; Hites, R. A., *Environ. Sci. Technol.* (2008), 42, 31-36.

6 Ren, N.; Sverko, E.; Li, Y.; Zhang, Z.; Harner, T.; Wang, D.; Wan,X.; McCarry, B. E., *Environ. Sci. Technol.* (2008), 42, 6476-6480.

7 Ren, G.; Yu, Z.;Ma,S.; Li, H.; Peng, P.; Sheng, G; Fu, J., *Environ. Sci. Technol*. (2009), 43, 9453-9457.

8 Chen, L.; Mai, B.; Xu, Z.; Peng, X.; Han, J.; Ran, Y.; Sheng, G; Fu, J., *Atmospheric*. *Environ.* (2008), 42, 78-86.

9 Zhu, J.; Feng, Y.; Shoeib, M., *Environ. Sci. Technol*. (2007), 41, 9453-9457.