

FORMATION AND SOURCES I -POSTER

DIOXIN EMISSIONS FROM INDUSTRIAL WOOD WASTE INCINERATORS

Takashi Ikeguchi and Masaru Tanaka¹

National Institute for Environmental Studies, 4-6-1 Shirokanedai, Minato-ku, Tokyo 108-8637, Japan ¹ Okayama University, 1-1 Naka 1-chome, Tsushima, Okayama 700-8530, Japan

Introduction

According to a nationwide survey in 1999 on dioxin emission from industrial waste incinerators average levels of polychlorinated dibenzodioxins and dibenzofurans (PCDD/Fs) of wood waste burning incinerators were 10.9 ng-TEQ/Nm³ (Min: 0 ng-TEQ/Nm³, Max: 79 ng-TEQ/Nm³, No. of incinerators: 592) while 10.3 ng-TEQ/Nm³ (Min: 0 ng-TEQ/Nm³, Max: 440 ng-TEQ/Nm³, No. of incinerators: 1,149) for a mixed waste incineration including wood waste¹. Major sources of wood waste are a lumbering, a wood products industry, and a construction/demolition site of houses. Those wood wastes have a variety of property by sources, i.e. wood with or without any chemical additive or treatment, wood coated or uncoated by other materials, and composite or non-composite wood, which may affect the level of PCDD/Fs in emission gases if incinerated. Especially a relationship between PCDD/Fs levels and chlorine contents in wood waste is much concerned. In this study wood chip obtained at a local lumber mill were burnt in a bench scale furnace with and without PVC resin or NaCl, and PCDD/Fs and their related compounds in flue gases were measured. Results were compared with other PCDD/Fs data obtained at several wood waste burning incinerators.

Methods and Materials

Incinerator used in this study is a two-chambered, fixed-bed type incinerator with a throughput capacity of 30 x 10⁴ kcal/hr. A cyclone is housed in the secondary combustion chamber, followed by a gas cooler. Larch tree chip with a size of 40-50 mm contained in a carton box were charged into furnace periodically during experimental RUNs. PVC resin or sodium chloride (NaCl) was added in wood sample in different amounts to change chlorine concentration in the waste. Combustion temperature (in the secondary chamber) was also controlled by a secondary burner.

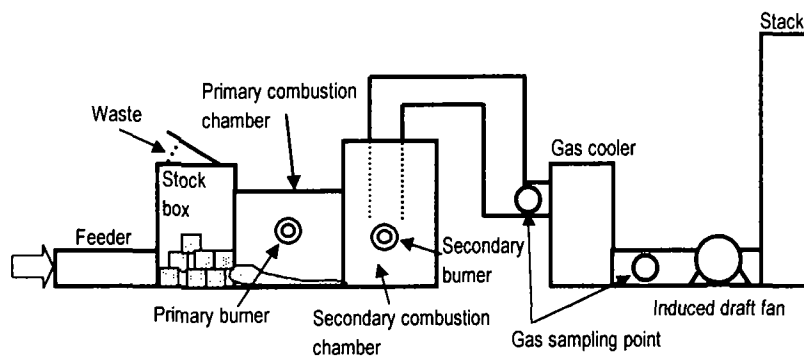


Figure 1. Schematic flow of bench scale incinerator.

FORMATION AND SOURCES I -POSTER

Combustion temperatures in the primary and the secondary chamber were monitored continuously as well as a flue gas temperature at gas sampling points. Dust, HCl and CO were measured at the outlet of the secondary combustion chamber, just before a gas cooler, and PCDD/Fs, Co-PCBs, Chlorobenzenes (CBz), and Chlorophenols (CPh) were measured before and after a gas cooler. Dust accumulated on water tubes in the gas cooler was washed out at the end of each RUN to eliminate a possible memory effect for a PCDD/Fs formation in the gas cooler. Schematic flow of a bench scale incinerator is shown in Figure 1.

Results and Discussion

Totally ten experimental RUNs were carried out as shown in Table 1. In RUNs 1-6 a secondary burner was turned on to complete waste combustion sufficiently with keeping combustion temperature at 1,000-1,100°C while a secondary burner was turned off in RUNs 7-10, resulting in 620-670°C of combustion temperature. Flue gas temperature before a gas cooler recorded 720-780°C and 460-490°C, for RUNs 1-6 and RUNs 7-10, respectively. On the other hand, after a gas cooler, flue gas temperatures were 150-180°C and 105-140°C for RUNs 1-6 and RUNs 7-10, respectively. Average amounts of waste burnt were 82-96 kg/hr for RUN 1-6, while 76-87 kg/hr for RUNs 7-10. RUNs 1 and 7 were blank tests and only larch tree chip were burnt. In other RUNs PVC resin was added with wood chip in 1%, 5%, and 10% in wet weight basis to observe the effect of chlorine contents on the formation of PCDD/Fs. Wood chip added by NaCl were also burnt to compare the PCDD/Fs formation in the case of PVC addition as a source of chlorine. Flue gases were sampled before and after a gas cooler for 4 hours to analyze PCDD/Fs and their related compounds.

Table 1. Experimental RUNs and measurement results.

Run#	Waste (% in wet basis)	Waste amount burnt (kg/hr)	Average combustion temperature (°C)		CO (ppm)	HCl (ppm)	PCDD/Fs (ng-TEQ/Nm ³)		Co-PCBs (ng-TEQ/Nm ³)		CBz (ng/Nm ³)		CPh (ng/Nm ³)	
			Primary chamber	Secondary chamber			Before gas cooler	After gas cooler	Before gas cooler	After gas cooler	Before gas cooler	After gas cooler	Before gas cooler	After gas cooler
1	Wood	95.7	716	1086	0.6	26	0.014	0.0073	0.000011	0.000018	170	220	140	770
2	Wood+PVC (1%)	94.6	650	1040	5.2	290	0.14	0.41	0.000038	0.012	350	790	280	3900
3	Wood+PVC (5%)	91.8	690	1076	5	2180	0.081	3.8	0.00001	0.099	240	2400	280	7800
4	Wood+PVC (10%)	82.3	666	1020	27.3	2890	0.15	7.7	0.000014	0.21	350	3500	370	13000
5	Wood+NaCl (5%)	85.8	715	982	4.3	530	0.11	1.7	0.0000075	0.064	250	1600	770	5700
6	Wood+NaCl (10%)	94.3	838	1063	75.2	870	0.15	1.4	0.0028	0.075	250	2100	370	3500
7	Wood	86.6	594	623	652	11	0.86	5.4	0.021	0.28	NA	4950	1050	3580
8	Wood+PVC (1%)	79.1	613	667	524	280	20	42	0.47	1.5	8950	9290	29620	42300
9	Wood+PVC (5%)	76.4	634	672	781.5	1600	84	170	2.9	8.8	40650	32000	128100	67840
10	Wood+PVC (10%)	75.5	609	625	1594	3700	580	820	17	35	110600	166000	439300	353300

Concentration is reduced at 12% O₂

PCDD/Fs measured before a gas cooler are shown against CO values in Figure 2. In RUNs 1-6 when the secondary combustion temperature was as high as 1,000-1,100°C, PCDD/Fs were nearly the same as 0.1 ng-TEQ/Nm³ except for the blank test irrespective of PVC or NaCl contents. PCDD/Fs level was 0.014 ng-TEQ/Nm³, extremely low at a blank test. On the other hand in RUNs 7-10 when the secondary combustion temperature was lower, PCDD/Fs increased from 0.86 ng-TEQ/Nm³ (blank test) to 580 ng-TEQ/Nm³ as PVC increased. Similar tendency was observed in CBz and CPh levels. CO levels were also higher in RUNs 7-10 than in RUNs 1-6. HCl increased as chlorine contents in wood increased as indicated in Figure 3. HCl was almost the same as far as PVC contents were similar and independent of the secondary combustion

ORGANOHALOGEN COMPOUNDS

FORMATION AND SOURCES I -POSTER

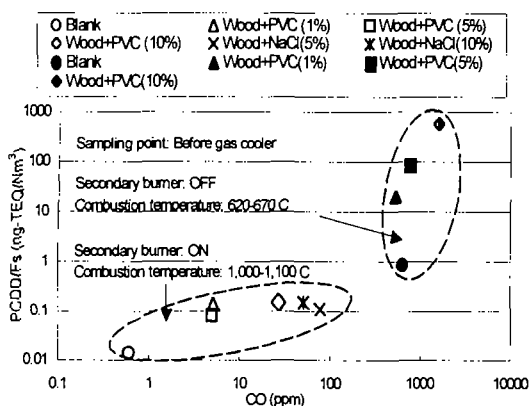


Figure 2. Relationship between PCDD/Fs and CO before a gas cooler

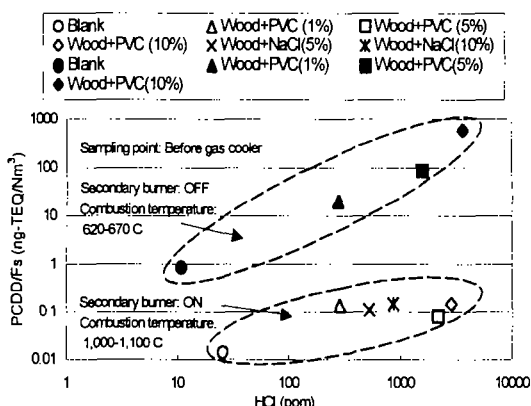


Figure 3. Relationship between PCDD/Fs and HCl before a gas cooler

temperature. HCl of the blank tests may be attributed to a chlorine originally contained in a larch tree or a carton box which was used for packaging wood chip to feed in the furnace. After a gas cooler, as expected, PCDD/Fs increased higher than levels before a gas cooler. Although PCDD/Fs in RUNS 1-6 were nearly the same before a gas cooler irrespective of PVC contents in wood chip, PCDD/Fs after a gas cooler increased as PVC contents increased.

Several PCDD/Fs measurements at wood waste incinerators in Japan are compared in Table 2. Incinerators are mostly a fixed-bed or a grate type, and a capacity ranges from 100 to 2,400 kg/hr. Air pollution control devices employed are a cyclone or/and a water spray. Three facilities have no air pollution control equipments. Available combustion temperature shows relatively high around

Table 2. Comparison of PCDD/Fs levels in flue gases of wood waste burning incinerators.

No	Wood waste incinerated	Incinerator type	Capacity (kg/hr)	Air pollution control***	Combustion temp. (°C)	Flue gas temp. (°C)	HCl (ppm)	PCDD/Fs (ng-TEQ/Nm³)	Sampling point	Ref.
1	C & D waste*	Fixed grate	160	None	840	665	120	15	Stack	2
2	C & D waste*	Fixed bed	195	C	775	481	140	16	After cyclone	2
3	C & D waste*	Fixed grate	190	C	716	858	92	31	Stack	2
4	C & D waste*	Fixed bed	190	W	NA	299	55	22	Stack	2
5	C & D waste*	Fixed bed	100	C	NA	379	18	8.2	Stack	2
6	C & D waste*	Fixed grate	600	W	785	380	1074	12	Stack	2
7	C & D waste*	NA	1250**	W+C	859	408	540	14	Stack	2
8	C & D waste*	NA	300**	C	922	429	56	57	After cyclone	3
9	C & D waste*	NA	1200**	C	569	177	109	2.6	Stack	3
10	C & D waste*	NA	1200**	C	1080	174	NA	5.1	Stack	3
11	C & D waste*	NA	200**	C	819	83	NA	16	Stack	3
11	C & D waste*	NA	190**	C	848	281	NA	12	Stack	3
12	C & D waste*	Fixed grate	2417	BF	NA	144	11.7	1.6	Stack	4
13	C & D waste*	Fixed grate	1250	ESP	NA	195	20.9	16	Stack	4
14	Cypress chip and bark	Fixed grate	420	None	NA	602	3.1	0.32	Stack	4
	Composite cypress wood				NA	569	6	3.9	Stack	4
	Ceder chip and bark				NA	719	7.4	0.38	Stack	4
15	Ceder chip and bark	Fixed grate	300	None	NA	550	6.1	0.13	Stack	4
	Imported ceder chip and bark				NA	660	25.6	0.28	Stack	4
	Cypress chip and bark				NA	540	4.1	0.37	Stack	4
16	Tree and grass clippings	Fixed grate	190	C	NA	630	45	2	Stack	2

*: Construction and demolition waste. **: Actual throughput during PCDD/Fs measurement.

***: C, Cyclone, W, Water spray, BF, Bag filter, ESP, Electro static precipitator

FORMATION AND SOURCES I -POSTER

700-1,100°C. Gases are sampled mostly at the sampling port of the stack or after a cyclone.

PCDD/Fs range from 0.08 ng-TEQ/Nm³ to 57 ng-TEQ/Nm³. Both maximum and minimum values are recorded at the facilities where construction and demolition wastes are incinerated. This means a burning of construction and demolition wood waste does not always generate high levels of PCDD/Fs. PCDD/Fs are likely to depend on the nature of wood, combustion parameters and facility line-up. However it may be true that PCDD/Fs in the flue gases of raw wood chip and bark are less than 1ng-TEQ/Nm³ at a normal combustion as measured at No.14 and 15 facilities. If artificial organic substances are contained with wood waste, however, as the cases of composite wood burnt at No.14, PCDD/Fs will increase from 0.32 ng-TEQ/Nm³ (cypress chip) to 3.9 ng-TEQ/Nm³ (composite cypress wood). Similar is applied to the results of PVC addition of this study, in which PCDD/Fs increased from 0.014ng-TEQ/Nm³ (no PVC addition) to above 0.1ng-TEQ/Nm³ (PVC addition) at higher secondary combustion temperature, and from 0.86ng-TEQ/Nm³ (no PVC addition) to above 20ng-TEQ/Nm³ (PVC addition) at lower secondary combustion temperature.

Conclusion

- (1) Although a burning of raw wood chip produced PCDD/Fs with the level of less than 1 ng-TEQ/Nm³ at both higher and lower combustion temperature, PCDD/Fs levels increased as PVC or NaCl was added to wood chip.
- (2) At higher combustion temperature around 1,000-1,100°C, PCDD/Fs measured before a gas cooler were nearly identical irrespective of PVC or NaCl contents whereas PCDD/Fs increased as PVC contents under lower combustion temperature.
- (3) After a gas cooler PCDD/Fs increased inevitably for all RUNs more than the levels before a gas cooler, and as PVC and NaCl contents in wood chip increased.
- (4) Construction and demolition wood waste dose not always produce higher levels of PCDD/Fs, but wood chip or bark incineration operated at the lumber mills generates PCDD/Fs of less than 1 ng-TEQ/Nm³ at a normal combustion even though facilities have no air pollution control devices.

Acknowledgements

This study was a part of research and survey results funded by the former Japanese Ministry of Health and Welfare (Supplementary Budget of FY 1998 for the Environmental Survey).

References

1. Yoneda K., Yagi Y., Ikeguchi T., Chichibu K., Nakamura Y., and Kawazoe S. (2001) Elsewhere in this proceedings.
2. Ikeguchi T. Unpublished data.
3. Yokoi K. (1999) Report prepared for the Training Course on Solid Waste Management at the National Institute of Public Health (in Japanese).
4. Ikeguchi T., Yoneda K. and Yagi Y.(2001) Research on PCDD/Fs formation and their control technologies for industrial waste incineration, Research report funded by the Health Sciences Research Grants from the Ministry of Health and Welfare (in Japanese).