PHOTODEGRADATION OF DIOXINS IN ETHANOL WASHING SOLUTION

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Introduction

Incineration of waste, soil, or solvents contaminated with dioxins has received considerable research attention based on its applicability for large volumes, short treatment time, cost effectiveness, and efficiency.[1] Such technology, however, has only been applied in a limited number of projects due to difficulties associated with centralized treatment, dioxin production, and exhaust monitoring; serious problems which have energized public groups in Japan to stubbornly oppose the construction of any local facility designed for treatment of dioxins. Consequently, and unfortunately, the remediation of dioxin-contaminated solvents by incineration has not emerged as an effective course of action.

Here, we describe ultraviolet (UV) treatment of the ethanol washing solution generated during remediation of dioxin-contaminated soil (also presented in this issue). In contrast to incineration, this UV method degrades dioxins without heating, *i.e.*, at room temperature and atmospheric pressure. Moreover, since the proposed treatment is relatively simple and requires no large components or complex equipment, it is highly suitable for incorporation as a mobile treatment facility; a major advantage that should promote public acceptance such that areas suffering dioxin contamination can be more quickly restored to their original condition.

Methods

Analysis of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) was performed using gas chromatography high-resolution mass spectrometry (HRGC-MS; GC, Hewlett Packard, 5890-2; MS, Nihhondenshi, Mstation-700).[2] Calculations were based on the International Toxicity Equivalency Factor determined by WHO/IPCS in 1998. The concentration of coplanar polychlorinated biphenyls (co-PCBs) was not determined.

Ethanol washing solution was filtered through a 0.22-μm hydrophilic membrane filter (Durapore, Millipore) and then irradiated in a crystal cell using a ramp-type 1.2-watt UV light (Toshiba Nanotype, FC1V36) encased in glass and installed within a reactor. We also performed a control experiment in which UV irradiation was stopped by covering the crystal cell with aluminum foil. All analyses were performed in triplicate (n = 3), with average values being indicated in the results.

Results and discussion

Table 1 summarizes dioxin concentrations before and after UV irradiation, where it can be seen that 2378- and non 2378-substituted isomers are almost completely degraded after 16 h. Only 2378-T4CDD showed relatively lower removal efficiency (*i.e.*, 96%, TEQ based), being due to its extremely low concentration of 7.8 pg/ml. The resultant average PCDDs/DFs removal efficiency based on either TEQ or concentration was 99.8 and 99.9%, respectively.

Table 1. 2378- and non 2378-substituted isomer concentrations before and after UV irradiation.

Dioxin	pg/ml				pg-TEQ/ml				
	Initial	Control	Final	Removal efficiency (%)	TEF	Initial	Control	Final	Removal efficiency (%)
2378-T4CDD	7.8	7.6	0.3	96.1	1.0	7.8	7.6	0.3	96.0
T4CDDs	303.0	272.7	1.8	99.3	-	-	-	-	-
12378-P5CDD	276.1	202.8	N.D	100.0	1.0	276.1	202.8	N.D	100.0
P5CDDs	1750.8	1895.6	4.6	99.8	-	-	-	-	-
123478-H6CDD	537.1	505.9	1.2	99.8	0.1	53.7	50.6	0.1	99.8
123678-H6CDD	712.2	688.3	N.D	100.0	0.1	71.2	68.8	N.D	100.0
123789-H6CDD	557.0	553.2	N.D	100.0	0.1	55.7	55.3	N.D	100.0
H6CDDs	7839.6	7766.3	12.2	99.8	-	-	-	-	-
1234678-H7CDD	2371.2	2469.1	1.6	99.9	0.01	23.7	24.7	0.0	99.9
H7CDDs	5123.3	5394.7	3.4	99.9	-	-	-	-	-
O8CDD	4141.0	4162.1	7.7	99.8	0.0001	0.4	0.4	0.0	99.8
Total PCDDs	23619.3	23918.3	33.0	99.9	-	488.7	410.2	0.5	99.9
2378-T4CDF	97.8	41.3	0.3	99.3	0.1	9.8	4.1	0.0	99.4
T4CDFs	3722.8	3778.3	15.6	99.6	-	-	-	-	-
12378-P5CDF	471.1	473.5	0.9	99.8	0.1	23.6	23.7	0.0	99.8
23478-P5CDF	1159.4	1138.8	2.5	99.8	0.5	579.7	569.4	1.2	99.8
P5CDFs	15862.0	16347.7	36.1	99.8	-	-	-	-	-
123478-H6CDF	2001.0	2123.1	4.4	99.8	0.1	200.1	212.3	0.4	99.8
123678-H6CDF	2724.8	2847.5	3.8	99.9	0.1	272.5	284.7	0.4	99.9
123789-H6CDF	1799.3	3181.0	6.4	99.8	0.1	179.9	318.1	0.6	99.8
234678-H6CDF	6336.9	6214.0	7.1	99.9	0.1	633.7	621.4	0.7	99.9
H6CDFs	37925.7	38560.1	48.2	99.9	-	-	-	-	-
1234678-H7CDF	6711.7	5970.9	2.0	99.9	0.01	67.1	59.7	N.D	100.0
1234789-H7CDF	1256.1	1080.1	N.D	100.0	0.01	12.6	10.8	N.D	100.0
H7CDFs	14693.6	13368.1	2.4	99.9	-	-	-	-	-
O8CDF	9584.4	9982.7	11.5	99.9	0.0001	1.0	1.0	0.0	99.9
Total PCDFs	104346.6	105107.0	141.3	99.9	-	1979.9	2033.8	3.5	99.8
Total PCDD/DFs	127965.9	129025	174.2	99.9		2468.5	2444.0	4.0	99.8

As shown in Fig. 1, in contrast to the control experiment, 16 h of UV irradiation remarkably degraded both PCDDs and PCDFs, being clear evidence of treatment effectiveness.

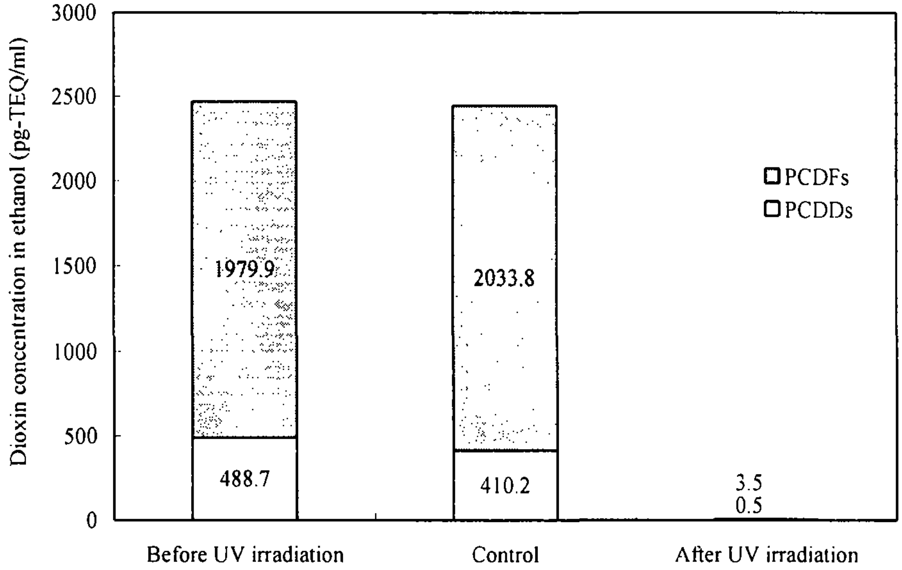

Fig. 1 Concentration of dioxins before and after UV irradiation.

Figure 2 shows HRGC-MS chromatography results for T4CDDs, where after 16 h of irradiation, most T4CDDs peaks have disappeared. The same holds true for other PCDDs/DFs peaks.

While the proposed method appears to be highly effective for treating a dioxin-contaminated ethanol washing solution, further research will be focused on developing a suitable system for treating solutions in which additions of H_2O_2, ozone, or other reactants are used.

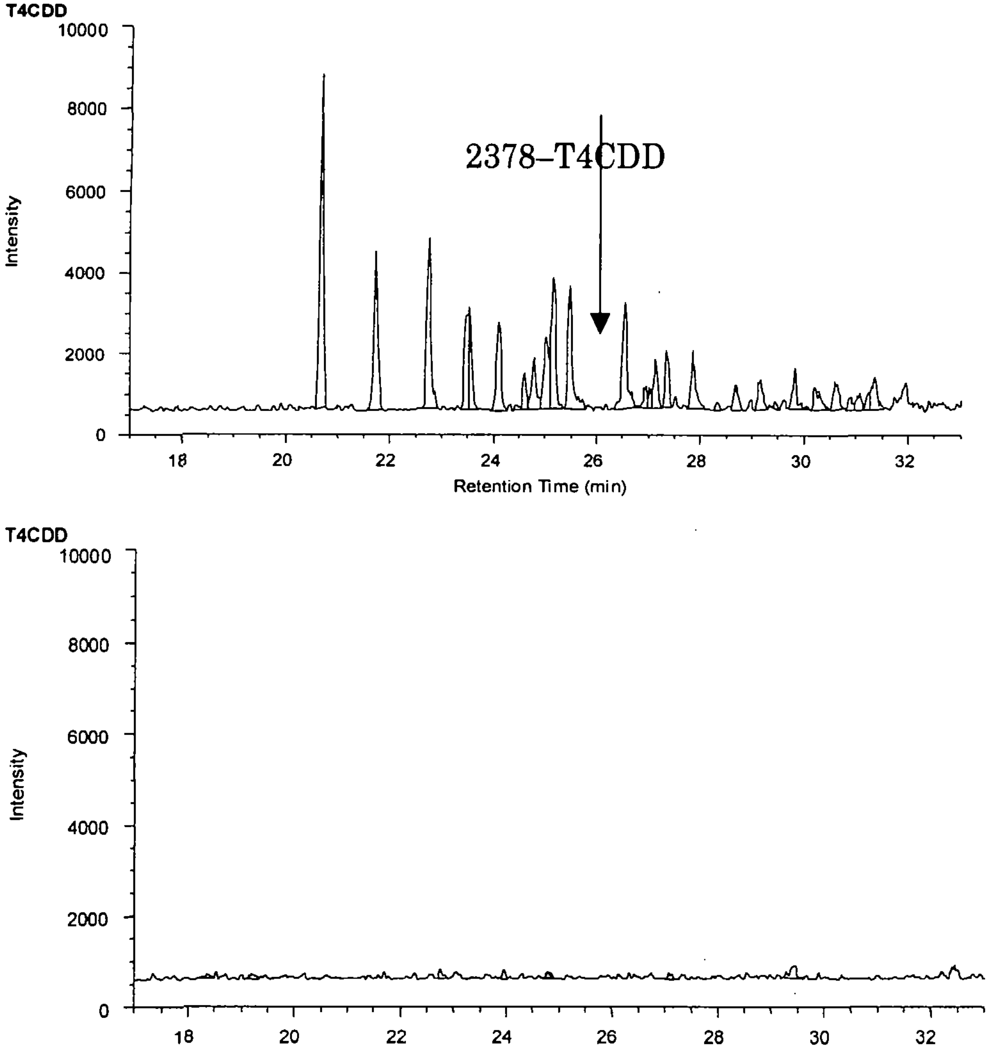

Fig. 2 Chromatography for T4CDDs before (upper) and after (lower) UV irradiation.

References

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