DESTRUCTION OF PCDD/Fs AND COPLANAR PCBs IN FLUE GAS FROM WASTE INCINERATION BY PHOTOCATALYST

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Introduction

Bag filter and catalyst system using the metals such as titanium or vanadium has been a principal technology for removing PCDD/Fs emitted from the waste incinerator. By introducing these systems, above 99% of PCDD/Fs in the emission gas can be removed[1,2]. But the temperature regions necessary for removing are below 200°C for bag filter and about 230°C for catalyst system. So, installation of large scale of gas cooling tower and re-heating reactor are indispensable[2]. Furthermore, to achieve the removal of PCDD/Fs efficiently, injection of activated carbon is also required as usual case. Therefore the installation and running cost of facilities becomes high. In Japan, there are tens of thousands of the waste incinerators beyond 50kg/hr in combustion, which are to be imposed legal controls after Dec.1, 2002. Most of these installations are operated by small incinerators without dust collector. Now, it is the most important problem for Japanese waste incineration facilities how to develop and realize the low cost and simple system to remove PCDD/Fs.

This time, we have developed a new system of technology for removing PCDD/Fs and Co-PCBs, named photocatalytic reactor (PCR), which is composed of TiO_2 photocatalyst and UV lamp. Using PCR, we have carried out the reduction test of PCDD/Fs and Co-PCBs in flue gas emitted from wood scrap combustion incinerator.

Methods and Materials

Silica gel particles (about 3mm in diameter) coated with TiO_2 film were used as TiO_2 photocatalyst[3], which surface areas are $300m^2/g$. The test was performed from Feb.17 to Mar. 17, 2000 at the wood scrap combustion facility (4.8t/8hr) in Tokai district of Japan. PCR is composed of the catalyst layer consisting of 95L TiO_2 photocatalyst and 16 units of UV lamp (Fig. 1). PCR was connected to the bypass line led from the outlet duct of cyclone. Sampling of flue gas was carried out 5 times (2/17, 2/24, 3/2, 3/11 and 3/24) at the inlet and outlet of PCR respectively. Methods of sampling and analysis were determined according to the Japanese Industrial Standard K 0311 (1999). Tetra- through octaCDD/DF were analyzed for PCDD/Fs, and 4 kinds of none-ortho and 8 kinds of mono-ortho PCB were analyzed for Co-PCBs.

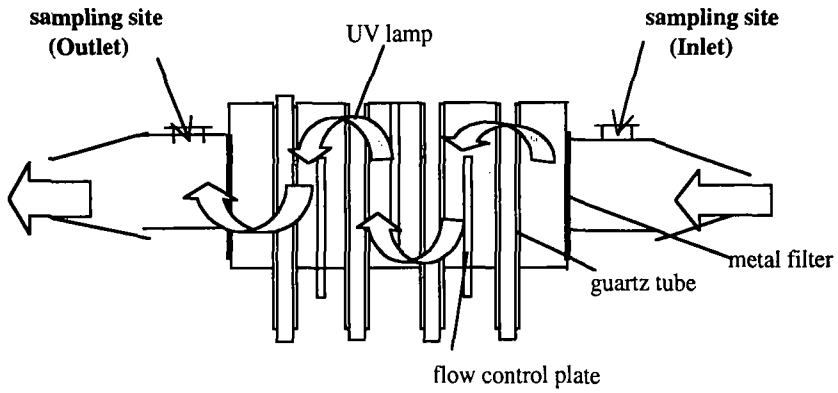

Figure 1. Schematic view of photocatalytic reactor

Results and Discussion

Data of flue gas in the vicinity of inlet PCR is shown in Table 1. Temperature of flue gas was varied from 190°C to 335°C and space flow velocity (SV) was varied from 570/h to 4,600/h. Analytical results of PCDD/Fs and Co-PCBs are summarized in Table 2. It was known that the emission of PCDD/Fs becomes maximum at around 300°C of gas temperature. In this study, it was found that Co-PCBs concentration becomes maximum at 271°C (Run 4) as same as PCDD/Fs. Concentration of PCDD/Fs and Co-PCBs of flue gas in the vicinity of inlet of PCR was 45 - 130ng TEQ/Nm^3 and 1.1 – 3.7ng TEQ/Nm^3 but decreased to 0.16 – 1.6ng TEQ/Nm^3 and 0.000036 – 0.052ng TEQ/Nm^3 in the vicinity of outlet. Removal efficiency of PCDD/Fs and Co-PCBs by PCR can be kept above 97% regardless of operating conditions.

Isomer patterns of PCDD/Fs and Co-PCBs are shown in Fig. 2. Considering the fact that the isomer patterns at inlet are similar to those at outlet and removal efficiency of all isomers are above 96% (Fig. 3), it was concluded that PCR has removal property to all toxic isomers.

Before proceeding to Run 3, catalyst was removed from PCR and concentrations of PCDD/Fs and Co-PCBs contained in catalyst were analyzed. As a result, it was found that PCDD/Fs and Co-PCBs of 3.84μg TEQ in the total volume of catalyst. On the other hand, total volume of those chemicals in total flue gas from the 1st to 21st day was calculated at 161μg TEQ. So, it can be said that the additional volume of PCDD/Fs and Co-PCBs to catalyst layer was only 2.4%.

Table 1. Flue gas data of PCR inlet

	Run 1	Run 2	Run 3	Run 4	Run 5
Date	2/17	2/24	3/2	3/11	3/17
Moisture (%)	4.3	15.7	10.5	14.9	6.1
Velocity (m/s)	2.9	3.0	9.4	8.4	4.0
Temperature (°C)	210	190	335	271	202
O_2 (%)	13.5	16.0	11.2	13.0	13.7
Gas volume flow (Nm^3)	55	54	170	140	80
SV (h^{-1})	580	570	4,600	3,800	2,200

Table 2. Analytical results of PCDD/Fs and Co-PCBs (ng-TEQ/Nm³)

	Run 1		Run 2		Run 3		Run 4		Run 5	
	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet	Inlet	Outlet
PCDDs	22	0.069	19	0.022	36	0.25	58	0.83	20	0.55
PCDFs	30	0.086	26	0.036	45	0.20	76	0.80	29	0.61
Co-PCBs	1.1	0.000036	1.4	0.000032	2.1	0.014	3.7	0.052	1.1	0.025

When TiO2 photocatalyst is irradiated with UV lamp under the existence of moisture and oxygen, hydroxyl radical (•OH) generates. It is known the extremely reactive species and can decompose organic substances oxidatively to CO_2, H_2O and inorganic ions finally. The result of investigation shows that TiO_2 photocatalyst has possibility to decompose fundamental structures of PCDD/Fs and Co-PCBs.

As illustrated above, PCR has high removal efficiency and consists of very simple system with far lower maintenance cost compared to the other systems. We are convinced that PCR system, in the near future, will be a main stream in the field of removal technology of PCDD/Fs and Co-PCBs in flue gas emitted from the waste incinerator.

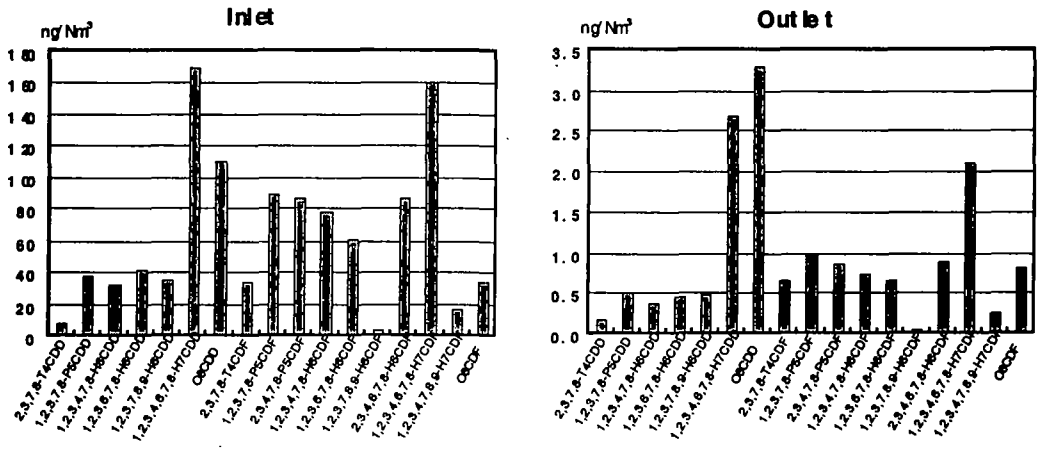

Figure 2a. PCDD/Fs Isomer pattern (Run 4)

References

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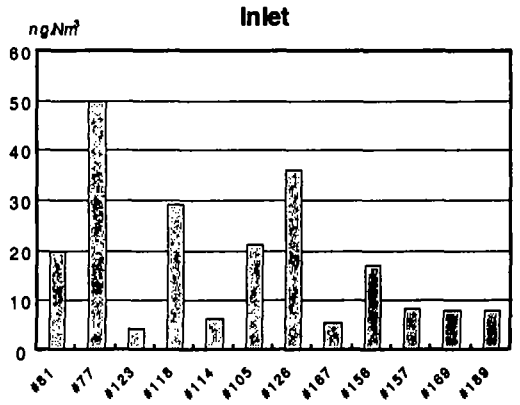

Figure 2b. Co-PCBs Isomer pattern (Run 4)

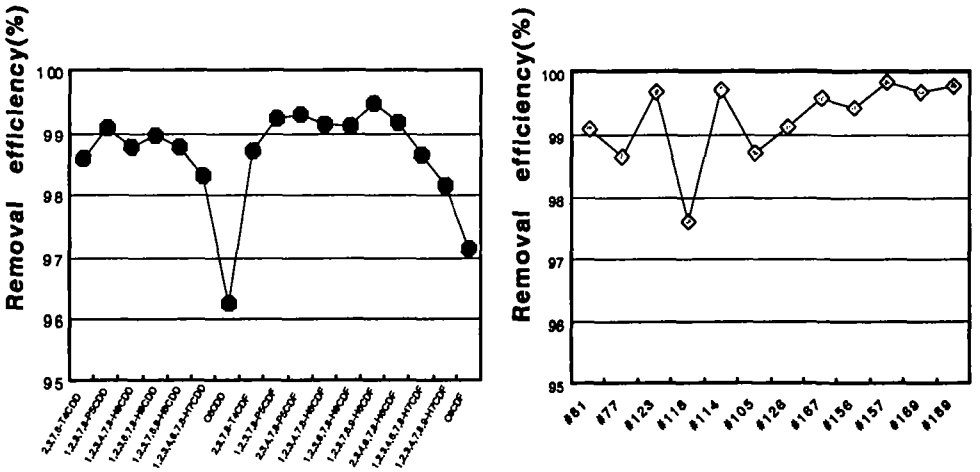

Figure 3. Removal efficiency of PCDD/Fs and Co-PCBs isomer