EFFECT OF AIR RATIO ON DIOXIN FORMATION IN MUNICIPAL SOLID WASTE INCINERATION

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Introduction

In our previous work, the effects of organic and inorganic chloride in municipal solid waste on the formation of polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) were examined. The results revealed that PVC has a greater affect on PCDD/DF emission than NaCl under CO-producing incineration conditions.[1)] As PCDDs and PCDFs are generated in pockets of unburned hydrocarbons or carbon, it is expected that their formation and emission may be influenced by combustion characteristics, and air ratios in particular. In this study, the effects of air ratio during combustion on PCDD/DF formation from organic and inorganic chloride are investigated using a laboratory-scale fluidized-bed incinerator. In the experiment, artificial solid waste (ASW) was used to ensure experimental accuracy.

Experimental Method

Figure 1 is a schematic of the laboratory-scale experimental incinerator used in the experiments. This incinerator was designed so as to allow factors such as the air ratio and temperature to be varied independently. The primary combustor was made of quartz with an internal diameter of 74 mm and a height of 1100 mm. The secondary combustor was a high-alumina tube with an internal diameter of 100 mm and height of 2000 mm. The temperature of the combustors was controlled using an electric heater, maintained at 800 °C and 900 °C, respectively. The flow rates of primary and secondary air were set to be identical and the total excess air ratio was varied from 1.6 to 2.0. The feed rate of ASW was 11 g/min at 2.0 air ratio. Flue gas was cooled by passage through a gas cooling section. The cooling section had an internal diameter of 83 mm and a length of 3000 mm, and its temperature was maintained at 300 °C via a water cooler and electric heater. Concentrations of O_2, CO and NO_X in the flue gas were continuously monitored at location S5 (see Fig. 1). PCDD/DF and

gas sampling was conducted over 2 hours at location S3. O_2, CO, and NOx concentrations were measured using a zirconia, non-dispersive infrared (NDIR), and chemiluminescence gas analyzer, respectively (Horiba PG-250). The methane equivalent total hydrocarbons (THC) were measured using a flame ionization detector (FID) (Horiba MEXA-1110FRF).

The main components used for the base ASW were paper powder (45%), wood powder (20%), flour (15%) and PE powder (20%). In order to restrict the Cl content to as low as possible, unbleached paper, pine wood, salt-free flour and virgin resin PE were chosen as the components. To adjust the Cl contents and change the Cl compounds, PVC, PVdC or NaCl was added to the base ASW.

Results and Discussion

Figures 2 and 3 show the PCDD/DF and CO concentrations, respectively, for PVC4%-ASW incineration with excess air ratios of between $\lambda = 1.6 \sim 2.0$. It is clear from the figures that reducing the excess air ratio results in an increase in PCDD/DF and CO emission. Figure 4 shows the PCDD/DF concentration during the incineration of PVC4%-, PVdC3%-, and NaCl4%-ASW at $\lambda = 2.0$. There is no clear tendency for organic chloride to generate higher levels of PCDD/DF emission compared to inorganic chloride. The conversion ratio of ASW chloride into hydrogen chloride at $\lambda = 2.0$ is shown in Fig. 5. Almost all of the chlorine in PVC is converted into hydrogen chloride, which is the Cl source for PCDD/DF.[2)] These results show that organic chlorides such as PVC and PVdC do not contribute to PCDD/DF formation at higher excess air ratios, despite the abundance of hydrogen chloride.

Figure 6 shows the histories of O_2, CO and THC concentrations during PCDD/DF sampling for PVC4%-ASW incineration at $\lambda = 2.0$ and $\lambda = 1.6$. Combustion at $\lambda = 2.0$ yields neither CO nor THC, and PCDD/DF formation is consequently inhibited, as shown in Fig. 2. In contrast, several peaks attributable to CO and THC are observed in combustion at $\lambda = 1.6$. The phase of these peaks coincide quite closely. The difference in the half width of the CO and THC peaks is attributable to the different sample times of the analyzing instruments; 45 s for the CO analyzer and 3 ms for the THC analyzer. The coincidence of these peaks is indicative of the generation of a spatially and temporally localized region with a sufficiently fuel-rich air mixture to produce PCDD/DF. The occurrence of such heterogeneities in the incineration process is depend on the volatility of the solid waste, the overall excess air ratio, and more importantly the turbulence or mixing intensity of the flow field.

These results show that PCDD/DF generation can be reduced significantly by avoiding the generation of localized fuel-rich region or promoting turbulence. Based on these findings, it is considered possible to incinerate organic chloride such as PVC, believed to be a major source of PCDD/DF, without the generation of PCDD/DF by realizing appropriate combustion conditions.

Acknowledgements

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References

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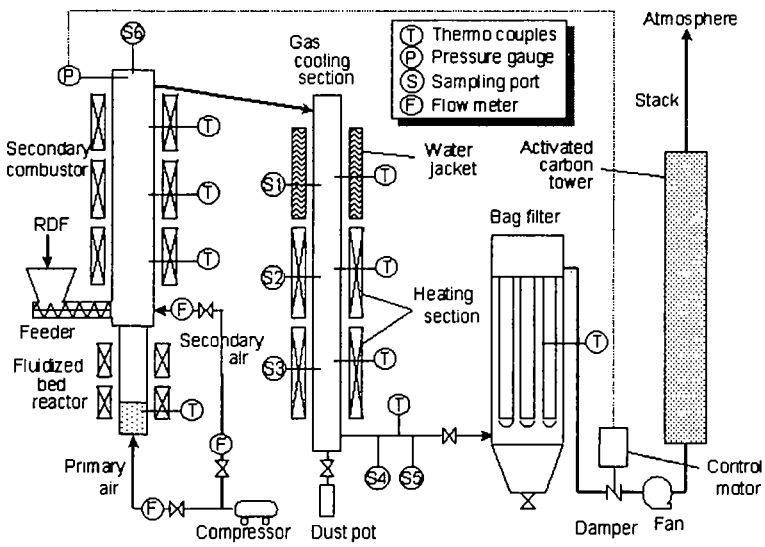

Fig. 1 Schematic of laboratory-scale experimental incinerator

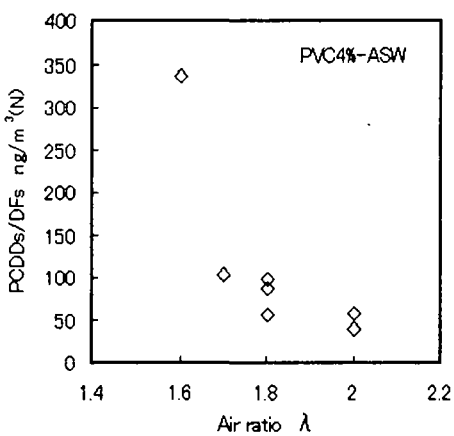

Fig. 2 Relationship between air ratio and PCDD/DF generation

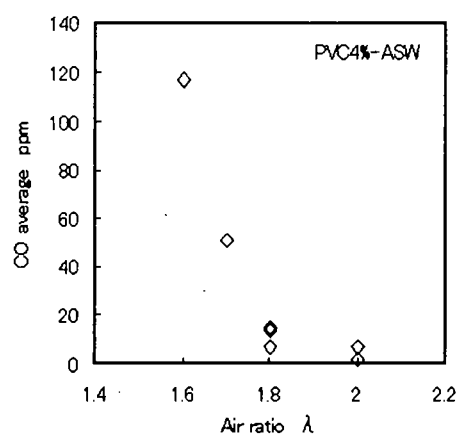

Fig. 3 Relationship between air ratio and CO generation

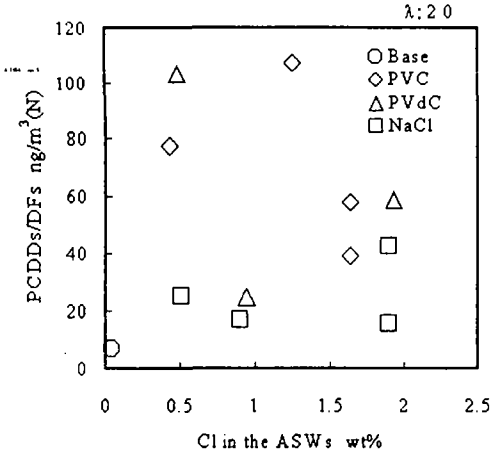

Fig. 4 Effect of source of Cl and the amount of Cl in ASW on PCDD/DF formation

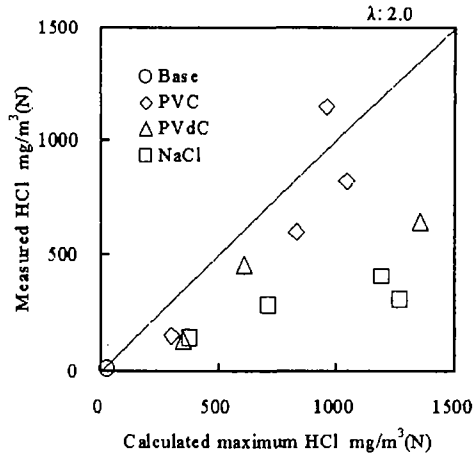

Fig. 5 Relationship between calculated maximum HCl concentrations and measured HCl concentrations

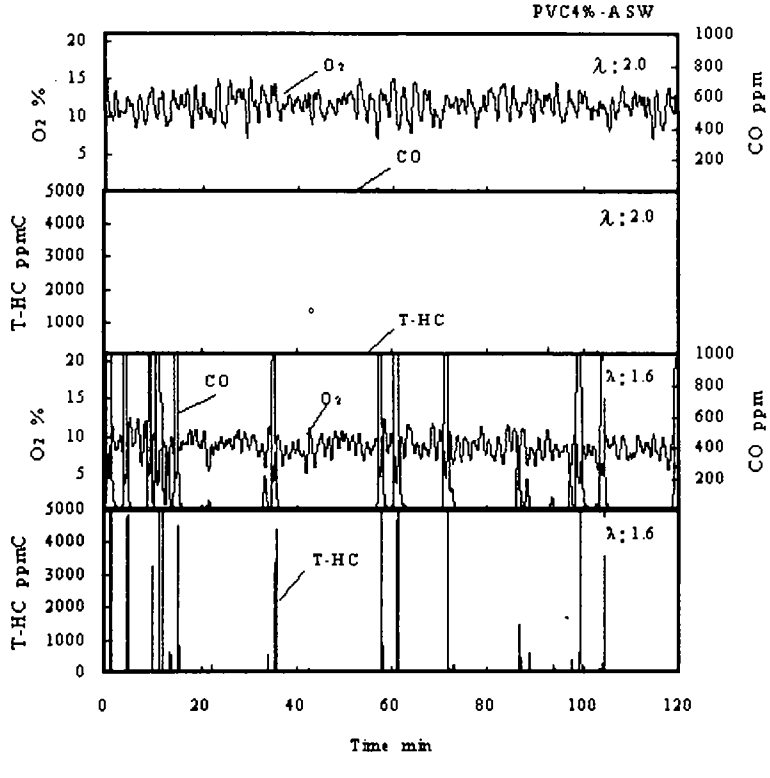

Fig. 6 Levels of O_2, CO and THC