

BASIC STUDY ON GAS/PARTICLE PARTITIONING OF PCDD/F

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Introduction

Polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/F) may be formed during the combustion of municipal and other waste. Due to their high toxicity, the emission limit for PCDD/F has been set as low as 0.1 ng TE/Nm³ in many countries. Most commonly, this limit is achieved and guaranteed by adding another installation to the flue gas cleaning train, like a coke or active carbon absorber. Although efficient, this procedure requires high installation and operation costs. Therefore, more economic ways are needed to control the PCDD/F emissions.

Due to their thermodynamic properties, the PCDD/F are usually partitioned between the gas phase and the particulate phase at temperatures below about 250 °C. The gas/particle partitioning depends on the congener properties, the temperature, the available particle surface and on the chemical composition of the particles. Large and even major PCDD/F fractions have been detected in the gas phase close to the dust filter. Usually, they escape the filter and pass all subsequent components, until they are removed in the final absorber just before the stack. Hence, significant cost reductions can be expected, if the PCDD/F emission control is achieved around the dust filter already. There are several proposals to do this. In the present work, experimental and theoretical studies are performed to enlarge the particulate fraction of the PCDD/F and to improve their removal during filtration.

Materials and Methods

With the help of a previously developed aerosol code, the diffusive transport of gaseous PCDD/F to the particle surface was calculated. As expected, the result shows that the gas to particle transfer increases with increasing particle mass concentration and with decreasing particle size. For particle diameters around 1 µm and mass concentrations around 100 mg/Nm³, the transfer rate is several hundred ng PCDD/F per Nm³ and per sec. A similar situation can be expected in typical waste incinerators. Therefore, the dust particles will constitute a substantial sink for PCDD/F, if the sticking factor is high enough. This needs experimental investigations.

In basic experiments, MWI fly ash particles with $d < 20 \mu\text{m}$ and a non-toxic hexachlorodibenzo-p-dioxin (HxCDD) were added separately to air and flue gas streams of 500 Nm³/h. The input concentrations of the fly ash and the dioxin were close to 100 mg/Nm³ and 50 - 90 ng/Nm³, respectively. The temperature was varied in the range 25 - 135 °C. Particle and gas samples were taken after a residence time of 1.5 sec, in order to determine the gaseous and particulate fractions of the dioxin.

The particle size distribution was measured by electron microscope, light scattering analyzer and impactor with good agreement of the results. The size distribution was approximately log-normal with a geometric mean diameter around 0.7 μm and a standard deviation $\ln \sigma_g \approx 0.6$ (Mätzing et al., 1998).

The gaseous and particulate fractions of the HxCDD were separated by two methods: combination of a glass fiber filter with XAD adsorber and combination of an impactor with XAD adsorber. Surprisingly, no reproducible results could be obtained, when the glass fiber filter was used to collect the particulate fraction. Further investigations are in progress to clarify this. Acceptable results were obtained with the combination of impactor and XAD adsorber.

Results and Discussion

Fig. 1 gives a plot of the measured concentration of gaseous HxCDD fraction as function of temperature. As expected, the gaseous fraction decreases with decreasing temperature. Fig. 1 implies an enthalpy of adsorption which is close to 50 kJ/mol. This is in the range of typical enthalpies of evaporation of polyaromatic hydrocarbons and it is much less than the estimated enthalpy of sublimation (Rordorf, 1989; Pankow and Bidleman, 1992). Further measurements are needed to confirm this result.

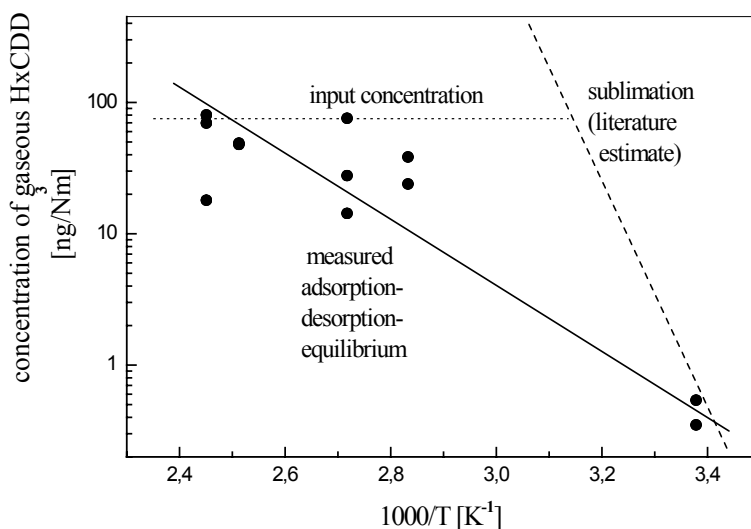


Fig. 1: Temperature dependence of HxCDD adsorption

References

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