

Determination of the PCDD/F Concentration in the Fumes from a PVC Fire

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1. Introduction

Recently it could be shown that chlorinated dioxins and furans (PCDD/F) are formed at various kinds of incinerations (accidental fires, waste incinerations, combustions in standard ovens, etc.) when chlorinated materials like PVC are involved^{1,2}.

In a study by Marklund et. al.³, an accidental fire in a wooden warehouse containing 200 tons of pure PVC and 500 tons of plastic carpets was investigated. The smoke remained close to the ground due to the inversion layer. The PCDD/F levels of the collected snow samples (the sampling areas were 20 cm x 25 cm and 2 cm depth) were in the range of 0.01-0.3 µg TE/m².

The laboratory incineration of PVC was also studied⁴. PVC samples were burned with a laboratory gas burner. The combustion products were condensed and collected on a cooled glass funnel placed upside down above the samples. The PCDD/F concentrations from the wipe samples were in the range of 0.2-1.2 µg TE/m².

There is a general controversy about the role of PVC as precursor for PCDD/F in municipal waste incinerations⁵. No significant increase in the amount of PCDD/F could be detected in the stack gas after adding PVC to the normal waste⁶.

Funcke et. al. investigated more than 200 samples taken from residues of PVC fire accidents⁷. In more than 90 % PCDD/F could be detected in the ppb and ppt range.

Since only the residues and wipe samples of these fires have been studied there is a general need to investigate the PCDD/F concentrations also in the fumes.

For this purpose we studied the PCDD/F concentration in the fumes from an open Wood/PVC fire in a closed hall.

2. Experimental

The sample technique of VDI 3498 was used. According to this instruction particles were separated from the gas phase with glassfibre filters, whereas gaseous PCDD/F were adsorbed on polyurethane-foam filters. Both sampling compartments were analysed separately.

To check particle breakthrough of the glassfibre filter (0.5-1.4 µm pore size) a second glassfibre filter was used as back-up filter. For the PCDD/F analysis in the gaseous phase both polyurethane-foam filters were united.

In the fire experiment 400 kg wood and 40 kg PVC were completely incinerated. The fumes dispersed throughout the closed hall (30 m x 15 m x 10 m). The temperature of the fumes

penetrating the sampler rising from 20°C to 80°C. Sampling lasted 45 min. with a flow rate of 30 m³/h.

Before sampling ¹³C₁₂-1,2,3,4-TCDD and ¹³C₁₂-1,2,3,7,8,9-HxCDD was brought on the filters according to VDI 3498. The clean-up procedure is described in a flow chart (Fig. 1). After addition of ¹³C₁₂-labeled standards the extracts were liquid chromatographed in several steps. The cleaned extract was injected into a HRGC/HRMS-system for identification and quantification. Recoveries generally varied between 70-110% and detection limits varied between 0.1-1.5 pg/m³.

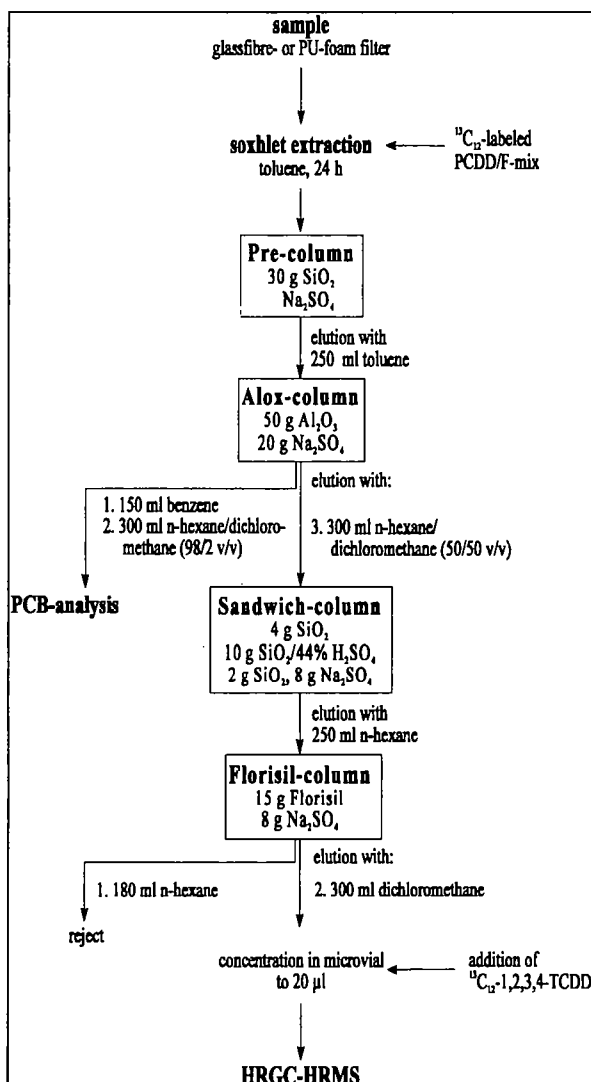


Figure 1: Flow chart of PCDD/F clean-up

3. Results and Discussion

In figure 2 the results of PCDD/F pattern in different filters are summarized. To separate the gaseous and particular bound PCDD/F two different filters were used. Glassfibre filters hold back the particular bound PCDD/F and polyurethane-foam filters adsorb gaseous PCDD/F.

The concentrations of PCDD/F in the fumes of PVC fire (about 5 ng TE/m³) are in the same range as the concentrations of PCDD/F in stack gas of municipal waste incinerators.

The PCDD/F pattern found in the different filters is very similar. The filters show a decrease from the tetra- to the octa-congeners.

The result of the back-up filter shows that about 10% of the particular PCDD/F break through the first glassfibre filter.

Surprisingly more than 90% of the PCDD/F were found on the polyurethane-foam filters. It shows that the formation of gaseous PCDD/F or particular PCDD/F <0.5 µm were formed under these fire conditions.

The high chlorinated PCDD/F (low vapour pressure) are favour to adsorb on particles, whereas the low chlorinated PCDD/F (higher vapour pressure) are present in the vapour phase under environmental conditions. This is not the case in the described fire experiment.

To estimate the PCDD/F deposition from these PVC fire a wipe sample on a 1 m² aluminium sheet was taken. The wipe sample showed the same PCDD/F pattern as the filters. The wipe sample level of PCDD/F was 50 ng/m² similar to the findings by Marklund⁹.

4. Conclusion

These results show that incineration of PVC in open fires result on considerable amounts of PCDD/F, which demonstrate the toxic potential of these industrial material in accidental fires.

5. References

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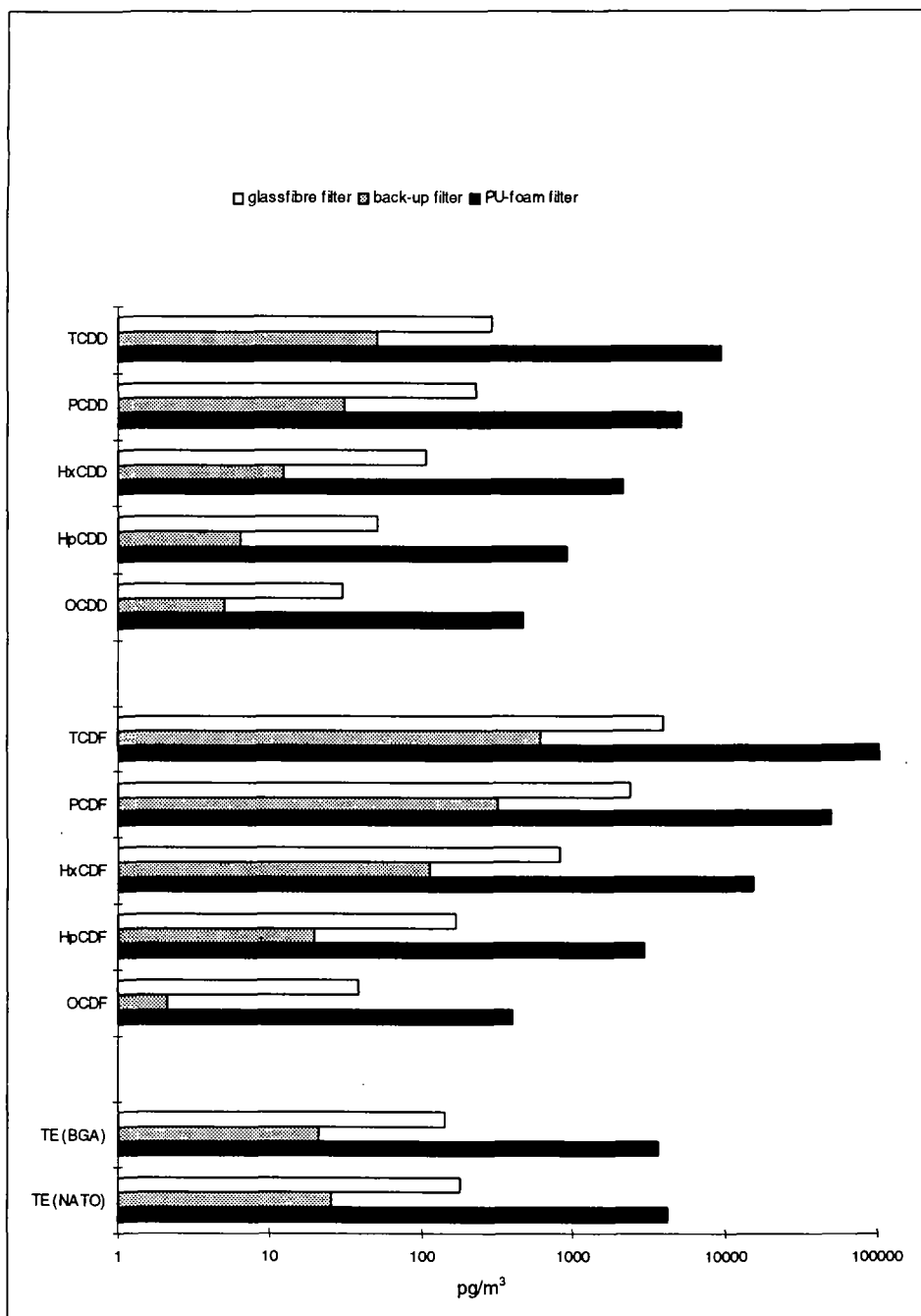


Figure 2: PCDD/F pattern of different filters