Measuring and Characterizing Tris (2-chloro-1-methylethyl) Phosphate Emission from Open Cell Spray Polyurethane Foam

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DISCLAIMERS

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SUMMARY
Understanding emission of Tris(2-chloro-1-methylethyl) Phosphate (TCPP) from spray polyurethane foam (SPF) insulation will contribute to the assessment of exposure to TCPP in indoor environments. This study aims to: (1) develop a method to determine the gas phase concentration of TCPP in equilibrium with the material phase (y_0) for open cell SPF, (2) determine the partition coefficient for TCPP between air and SPF (K), and (3) examine the influence of temperature on y_0 and K. The emission of TCPP from two kinds of open cell SPF in a closed micro-chamber without flow are being tested. The steady-state gas phase TCPP concentration in the chamber (C_{equ}) is also being measured. C_{m0} (the initial concentration of TCPP in SPF) is measured using a solvent extraction method. C_{equ} and C_{m0} will then be used to determine y_0. These measurements are still in progress, and the preliminary results will be presented at the conference.

PRACTICAL IMPLICATIONS
The parameters (y_0 and K) derived in present study can be used to predict TCPP emission from SPF in full scale indoor environments.

KEYWORDS
TCPP, Flame Retardant, Indoor Environment, Exposure, Spray Polyurethane Foam

1 INTRODUCTION
The desire to create more energy-efficient buildings in the United States has increased the application of spray polyurethane foam (SPF) insulation to reduce building envelope heat loss. Two different kinds of SPF, open cell (low density) and closed cell (medium density), can be produced on site via an exothermic reaction of two sets of chemicals. One of the main components in SPF is the flame retardant Tris(2-chloro-1-methylethyl) Phosphate (TCPP), which can be present in foam at a concentration up to 12 % by mass (Sebroski, 2012). Since TCPP is not chemically bound to the polymer matrix, TCPP may be emitted from the SPF after installation. Exposure to TCPP has been associated with asthma, reproductive and developmental problems (USEPA, 2014). Understanding the emission of TCPP from SPF will contribute to the assessment of exposure of TCPP in indoor environments and the development of strategies to control potential exposures. Previous studies have shown that emission of TCPP is likely externally controlled (convection) for open cell SPF, while it is controlled by both internal diffusion and convective process for closed cell SPF (Poppendieck et al., 2016). This study aims to measure the emission parameters of TCPP (y_0 and K) from open cell SPF and examine the influence of temperature on those parameters.

2 MATERIALS/METHODS
Figure 1 shows the schematic of chemical emission from SPF in a closed chamber. Based on mass balance at equilibrium:

$$V_m C_{m0} = K V_m C_{equ} + V_a C_{equ} + K_s A_s C_{equ} \quad (1)$$

Where, C_{m0} is the initial concentration of TCPP in SPF (μg/m^3), V_m is the volume of SPF (m^3), K is the partition coefficient for TCPP between air and SPF, C_{equ} is the equilibrium TCPP concentration in air (μg/m^3), V_a is the volume of air in the chamber (m^3), K_s is the partition coefficient of TCPP between the chamber wall and air, and A_s is the area of adsorption surface (m^2).

- C_{equ} is measured using a 1 L chamber and thermal desorption-gas chromatograph/mass spectrometer (TD-GC/MS) system. A small piece of SPF is placed in the chamber (Figure 2). The air concentration in the chamber can be measured by taking a 10 mL sample. When the concentration difference between two successive samples (sampled every hour) is less than 5 %, the emission process is considered to have reached equilibrium and the measured concentration is used as C_{equ}.

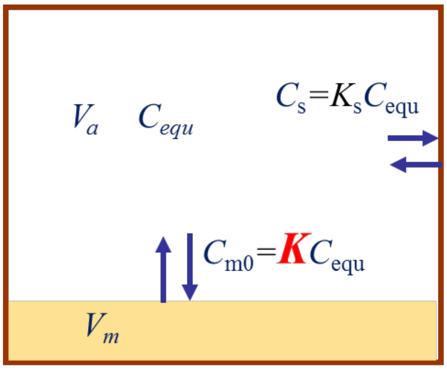

Figure 1 Emission process in a closed chamber

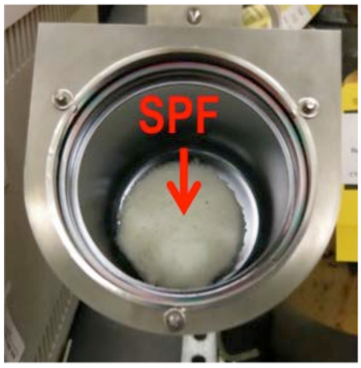

Figure 2 Photo of the chamber

- C_{m0} is measured by cutting the SPF into small pieces, extracting the sample ultrasonically with hexane/methanol four times and measuring the TCPP concentration in the extract using GC-MS.
- V_m is calculated based on the mass and the measured density of the SPF. V_a is calculated by substracting V_m from the total volume of the chamber (1L).
- Since C_{m0} is very large in SPF (around 10^9 μg/m^3), $K_s A_s C_{equ}$ is negligible compared to $V_m C_{m0}$ and can be removed from equation (1). Then K can be calculated, if C_{equ}, C_{m0}, V_m, and V_a are known. The gas phase concentration in equilibrium, y_0 can be calculated as C_{m0}/K.

3 RESULTS AND DISCUSSION

These measurements are still in progress. Preliminary results will be presented at the conference.

4 CONCLUSIONS

The parameters (y_0 and K) derived in the present study can be used to predict TCPP emission from SPF in indoor environments.

5 REFERENCES

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