Uptake of Semi-volatile Organic Compounds onto Ammonium Sulfate Particles

Andersen C.[1], Eriksson A. C.[1], Krais A. [2], Clausen PA[3], Jakobsson J.[1], Löndahl J.[1], Wierzbicka A.[1], Gudmundsson A.[1], Pagels J. [1]

[1]Ergonomics and Aerosol Technology, Lund University, P.O. Box 118, SE-22100, Lund, Sweden
[2] Department of Laboratory Medicine, Lund University, SE-221 85 Lund, Sweden.
[3] National Research Centre for the Working Environment, Copenhagen Ø, 2100, Denmark

Keywords: AMS, adsorption, Indoor aerosols, Phthalates.

Presenting author email: christina.andersen@design.lth.se

Semi-volatile organic compounds may be taken up by aerosol particles through adsorption to the particle surfaces. Benning et al. (2013) showed with off-line techniques that Di-(2-ethyl-hexyl) phthalate (DEHP), a known endocrine disruptor is readily taken up by ammonium sulfate particles when these particles passes above vinyl flooring containing DEHP. This uptake also led to increased emission rates of DEHP from the flooring, which is of relevance for exposure to DEHP and other semi-volatile compounds in indoor air. Another experimental situation where uptake of SVOCs on particles is of importance is contamination of particle surfaces when flowing through conductive silicone tubing (Yu et al. 2009) or tygon tubing in experimental set-ups.

Here we used real-time electron ionization Aerosol Mass Spectrometry (AMS) to follow the dynamics of the uptake of DEHP onto aerosol particles when passed above vinyl flooring in a well-characterized small chamber. In the chamber the aerosol flows between two vinyl flooring surfaces. The chamber dimensions are 0.45 m x 0.25 m x 0.019 m (volume 1.2 dm^3). The chamber has been modified to improve internal mixing and reduce the sink effect (Wu et al. 2016). PVC flooring containing DEHP (15-23%) as the sole phthalate compound was chosen as the source material as it has proved to be a stable and constant emission source for DEHP.

The AMS is an online technique for determination and quantification of aerosol composition. It allows high time and mass resolution, as well as separation of most ions with the same m/z ratio. As a first step, calibration of DEHP was carried out on size selected particles using a condensation particle counter (CPC) and the AMS in parallel. The relative ionization efficiency (RIE) of DEHP with respect to ammonium nitrate was derived to be 4.4 ± 1.0. The RIE of a compound describes the sensitivity of the AMS towards this compound compared to nitrate which is the main calibrant.

Ammonium sulfate (AS) particles in concentrations of 40-160 µg m^{-3} were passed through the chamber (20 °C) at flow rates of 0.2-0.6 L min^{-1} resulting in average retention times of 2-6 min in the chamber. The calibration of DEHP formed basis for the quantification of DEHP uptake on AS particles. The intensity at the m/z ratio of 149, which is specific for DEHP, to the total signal of the entire molecule was applied to quantify DEHP. In Figure 1 a time series of repeated cycles, where AS particles are passing through the chamber, is shown. In these preliminary experiments we found a weak background signal of DEHP in the AS particles (about 0.2%) bypassing the chamber. A strong increase in the DEHP concentration was observed when AS particles passed the chamber. After around 15 minutes a plateau was reached, suggesting that the AS particles reaches a stage of saturation to DEHP. The uptake of DEHP on AS particles ranges from 1.5-2.1% of the AS mass. Approximately 30% of the AS mass was lost when passing through the chamber.

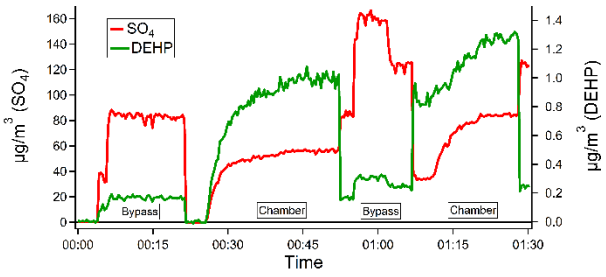

Figure 1 Time series showing repeated cycles with Ammonium Sulfate passing the chamber.

Results from this study show that the AMS has a four times higher sensitivity to DEHP compared to nitrate. This was used to quantify the uptake of DEHP on AS particles which ranged from 1.5-2% by mass.

These results will form basis to develop a controlled method to expose humans to study and quantify the uptake of phthalates into the human body. The results will help improving health risk assessment for the phthalate uptake.

This study was financed by the Swedish Research Council FORMAS.

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