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Water uptake and retention by filter material used for PM sampling

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Water uptake by atmospheric aerosol particles under conditions of elevated relative humidity is a well known phenomenon. Several models exist to predict the amount of water associated with the particles from their chemical composition. For PM measurements, weighing protocols have been developed that specify equilibration of filters at 50% humidity and 20°C for 24 hours before weighing. Under these conditions, most of the water should have evaporated from the particles. Recently, equilibration at 35% relative humidity has been suggested.

The question whether the filter material itself adsorbs water has been mentioned several times, but very few actual measurements (e.g. Demuynck, 1975; Hänninen et al., 2002) can be found in the open literature. If sampling was performed at elevated humidities and the filter material retains appreciable amounts of water vapor at the specified humidity for weighing even after the required equlilbration time, measured PM mass concentrations will be overestimated. As filter masses are much higher than deposit masses, even mass increases below the percent range will add a substantial bias to the measured deposit mass.

In this study, we investigate the changes in filter mass for different filter types (e.g. Quartz fibre, cellulose ester, glass fibre, polycarbonate filters) after 24 hr exposure to different humidities. We used the humidity chamber developed at the University of Vienna (Hitzenberger et al., 1997, current design: see Lehtinen et al., 2003). In this chamber (Figure 1), samples are put on an aluminum tray which is connected through a sealed opening to a semi-microbalance (Mettler AT 201, accuracy ± 10µg) mounted above the chamber. Humidity is controlled by using aqueous solutions of salts (in this study, we used $MgCl_2*6H_2O$) of different concentrations.

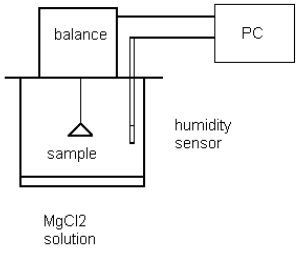

Figure 1 schematic set-up of the humidity chamber

Measurements started at ambient humidity in the laboratory (usually around 50%), when the balance is tared so the mass readings during th emeasurement cycle directly correspond to the mass of water taken up by or lost from the filters. Mass, temperature and humidity are recorded automatically. In a typical measurement, filters are first exposed to a nominal humidity of 30% (in some cases 40%) and subsequently to 50%, 90%, 50% and 30% (or 40%)40%. Exposure time at each of these humidities was > 24 hrs.

First results showed that during the periods at high humidities, filters can take up appreciable amounts of water. For 5 different 47 mm diameter Quartz fiber filters (Pallflex Tissuequartz 2500 QAT-UP), masses increased on average by 6.13 mg when humidities were increased from 43 to 87%. Most of this mass is lost again, but at 53 % the average mass increase is still 1.4 mg (compared to the initial 43%). The filters do not reach their initial mass when humidities are reduced back to 43%, but still retain 0.54 mg on average. In terms of filter mass, this mass increase is negligible (average mass of filters: 130.5 mg), but in terms of deposit mass, this mass retention could lead to large errors at low mass deposits.

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