Measurements of particulate matter hygroscopicity in Aerosol Exposure Chamber to prevent atmospheric corrosion in Data Center

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Data Center energy consumption amounts to ~27% of energy demand in Western Europe. About 35-50% of this energy is used by air-cooling system to remove the heat generated by electronic circuit activities (Shehabi, 2009). A recent solution to save energy consists in using an outside airflow to cool informatic technology (IT) equipment. This system, called Direct Free-Cooling, involves the risk to introduce particulate matter (PM) which can operate electrochemical corrosion once it deposits on ITs and reaches deliquescence conditions. Furthermore PM can arrange electrical conductive bridges which can cause the failure of ITs (Shehabi et al., 2008). ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) Technical Committee 9.9 guidelines recommend air thermodynamic conditions only to prevent corrosion process. It suggests to estimate deliquescence relative humidity (DRH), but it avoids to consider both the aerosol chemical composition – which drives the aerosol DRH – and the crystallization relative humidity (CRH).

Systematic studies of DRH and CRH changes related to the aerosol chemical composition, which in turn varies in space and time, are missing.

For these reasons, DRH and CRH were experimentally investigated in this study by electrical conductive measurements. In this respect, PM2.5 atmospheric samples collected at two sites, Milan (45°31'19"N, 9°12'46"E) and Oasi Le Bine (45°8'17.24"N, 10°26'10.99"E), were used to characterize respectively the urban and rural PM hygroscopic behaviour in the Po Valley (North Italy). Conductivity was measured in an Aerosol Exposure Chamber (AEC) – specifically designed for this study by Atmospheric Chemistry Research Group in Milano–Bicocca University – as a function of the relative humidity (RH) which was controlled by 1% step. Conductivity measurements were carried out using the Hewlett-Packard 3421A Data Acquisition Module while RH was monitored by LSI-Lastem termoigrometer sensor.

The inorganic ionic chemical composition of the 15 samples was also determinated by ionic cromatography (for cations: Dionex ICS-90 and for anions: Dionex ICS-2000) system. Data from chemical analysis were used to model hygroscopicity of collected particles by using the water moles output of the thermodynamic Extended-Aerosol Inorganics Model (E-AIM II, Clegg et al., 1998) Experimental data from AEC and model result were then compared (Figure 1).

Conductivity analysis on PM2.5 show hysteresis behaviour (Figure 2).

Data from AEC analysis of the 15 $PM_{2.5}$ show an average DRH of 61.38±1.68% and CRH of 47.12±1.58%. E-AIM modelled results estimate an average DRH of 63.00±2.16%.

These results are very useful to improve knowledge about the thermodynamic conditions which can cause corrosion processes triggered by atmospheric aerosols.

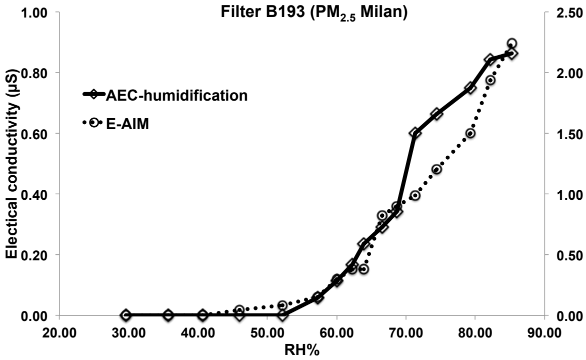

Figure 1. Aerosol conductivity curve (electrical conductivity; µS) during AEC air humidification and hygroscopic growth (H_2O; µmol/m^3) modelled by E-AIM II.

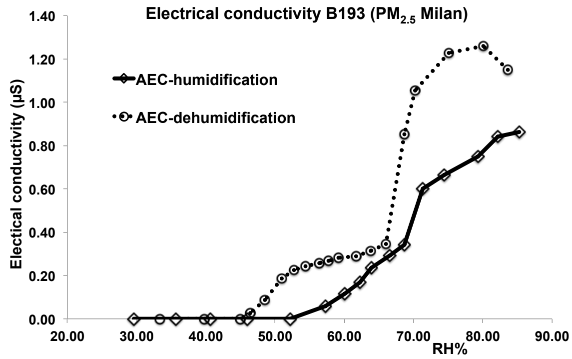

Figure 2. Aerosol conductivity curve during indoor AEC air humidification and dehumidification.

ASHRAE whitepaper (2011), *Gaseous and particle contamination guidelines for data center*.

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