EXPERIMENTAL MEASURE OF DRH AND CRH OF PARTICULATE MATTER FOR CULTURAL HERITAGE APPLICATIONS

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Abstract

Phase transitions and moisture adsorption property of Particulate Matter deposed on surfaces can determine decay process. Number of dissolution-crystallization cycles and time of wetness are very important decay-indicators. Deliquescence and crystallization of complex mixtures show an hysteresis behavior that depends on the chemical composition. In this work DRH and CRH experimental measurement of PM are used to compute decay-indicators for heritage materials. In this way the derived decay-indicators are representative both of a specific climate and pollution pattern.

1. Introduction

Atmospheric Particulate Matter can cause damage to heritage materials as a consequence of deposition process. PM is a complex mixture of substances, in which each component can play a specific role in decay phenomena [1,2,3]. Deliquescence and crystallization properties of deposited particles are fundamental for understanding decay process in action on artefacts. Although DRH of pure salts is a well-known parameter, during hygrometric variation, complex mixtures are subject to hysteresis cycles with DRH>CRH. The hysteric behaviour depends on the whole chemical composition. In this work a method based on conductance measurements, is employed to experimentally determine DRH and CRH of aerosol particles. PM samples collected on PTFE filters, are placed on a specific-designed conductance cell in an environmental-controlled chamber [4]. In this chamber, humidification and dehumidification cycles can be performed. Measuring conductance Vs RH, it is possible to derive DRH and CRH experimental values. These measurements can be coupled with climatic data to compute decay-indicators such as time of wetness (*TOW*) and number of dissolution-crystallization cycles (*NCy*) [5,6]. Using DRH and CRH experimental measures, the derived decay-indicators are representative both of a specific climate and pollution pattern. These measures could be also useful to assess the optimal hygrometric conditions in museum environments. Such a strategy has been already successfully employed for corrosion prevention in data-center.[4]. Since the aim of the research is to evaluate the impact of PM in the decay of heritage materials, a new sampler has been designed and built with the aim to collect PM directly on surfaces of interest.

2. Method and Results

Measure were made in an environmental-controlled chamber named Aerosol Exposure Chamber (AEC) [4]. This is a $1m^3$ glass box in which it is possible to vary the relative humidity (RH) conditions by inlet pure aqueous vapor (humidification) or pure dry air (dehumidification). During both humidification and dehumidification, conductance of $PM_{2.5}$ samples, collected on PTFE filters, was monitored using an Agilent 34411A 6 ½ multimeter. Conductance cells are made by two brass clamps at calibrated distance and a filter-holder.

Conductance Vs RH experimental curve of a typical $PM_{2.5}$ sample is shown in fig.1. DRH and CRH points were derived looking at the maximum point of derivative curves. Introducing DRH and CRH experimental values in the hygrometric profile, decay-indicators can be computed. Relative Humidity hourly averages in Milan are collected from ARPA (www.arpalombardia.it). A specific computing routine was develop to calculate TOW when particles are wet (RH>DRH), and a dissolution-crystallization cycles only when RH decrease under CRH starting from a wet condition (fig.2a). Results are shown in fig.2b: *TOW* is expressed as percentage of hours in the months, number of dissolution-crystallization cycles (*NCy*) is expressed as monthly average. The results are referred to a ten-years time horizon for the city of Milan. The graph shows the month-predominant decay process, depending on climate and PM composition.

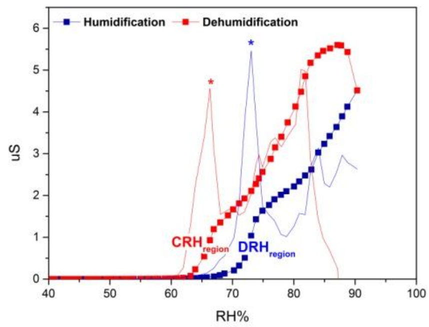

Fig.1: Typical conductance Vs RH curve obtained for $PM_{2.5}$ sample.

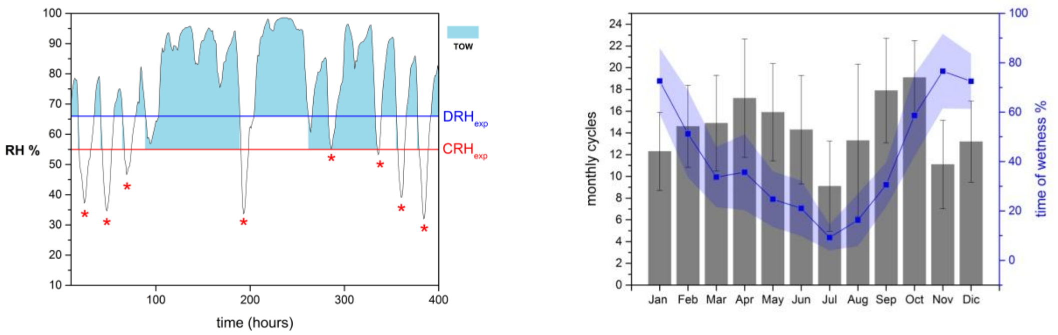

Fig.2: A) Example of algorithm for computing *TOW* and *NCy*. B) Monthly average results for the city of Milan (2003-2012).

3. Limitation of the Method and Future Perspectives

It is well known that the chemical composition of soiling is quite different from PM's ones. However the composition of soiling is the result of chemical and physical interaction between deposed PM, deposition surfaces and surrounding microclimate. For these reasons a new sampler has been designed and built with the aim to measure DRH and CRH of PM directly deposed on surfaces of interest, such as stone specimens. The samples is made of a 50x50cm exposure box, covered by a pitched roof. The air exchange in the box is standardized by a low-flux fan. A three-months sampling test was performed using some different materials as passive surfaces. The first results in term of TSP deposition rate show a very good repeatability (fig.3).

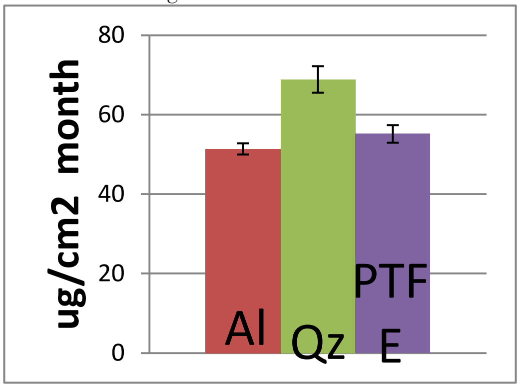

Fig 3: deposition rate obtained during the sampling test.

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