Identifying the sources of atmospheric particles in museum environments

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1. Introduction.

Preventive conservation implies, i.a., the characterization of the atmospheric environment around monuments or cultural heritage (CH) items, with the intention to improve the conditions and to contribute to the preservation of CH items. While earlier, much interest was on e.g. sulphur dioxide and its effect on building materials, the focus has now shifted to the indoor environment and to atmospheric particles in, e.g., museums. Analytical chemistry does play a key role in the chemical characterisation of the environment and it appears that X-ray spectrometry (XRS), in its many forms, is one of the most relevant analysis techniques, as it is in CH research in general (concerning the methodology used by the artists, provenancing and the discovering of forgeries, and the preparation for restorations).

2. Experimental.

We have, over the last decade, intensively used various forms of XRS, namely energy-dispersive X-ray fluorescence e.g. with polarized high-energy beam excitation, and automated electron probe X-ray microanalysis, together with ion chromatography, micro Raman analysis, on-line soot determinations, gravimetric mass determinations, etc., to identify particle types and their sources in indoor environments, including museums, while also gaseous indoor pollutants were assessed using passive diffusion samplers. In each case, both bulk aerosols and individual aerosol particles were studied. For microanalysis of single particles, we have investigated a dozen techniques, but for wide, real-life applications, automated electron probe X-ray microanalysis appeared to be still the most rewarding approach.

3. Results and discussion.

We have first studied atmospheric aerosols in and around e.g. the Correr Museum in Venice, in many other museums in Austria, Japan and England, and in the caves with prehistoric rock paintings of Altamira. More recently, similar and more extended atmospheric characterization measurements were also done in the Metropolitan Museum of Art in New York and the Wawel Castle museum in Cracow, in Italian and Polish mountain churches with many CH treasures, in a number of museums in Belgium and the Netherlands, and in cathedrals with medieval stained glass windows. Soon, studies will be done in the National Tile Museum in Lisbon, and, within the EU program TeACH, also in museum and historical buildings in Oslo, Bilbao, Cologne, Firenze, Cracow and in Morocco.

E.g. in the Correr museum, it appeared that the particles that were most threatening for the Bellini paintings in two specific rooms were released by the deteriorating plaster renderings, and this could be avoided by simply covering the walls in those rooms by a suitable paint or replacing the plaster. In the Wawel Castle, outdoor pollution particles, like fine soot from diesel traffic, and street de-icing salts and deposited coal fly ash, brought in under their shoes by visitors, were found to be most worrisome; remedies included the manual removal of snow near the museum entrance in winter, having more sticky mats at the entrance and avoiding very fine particles to enter through leaks around windows and doors by sealing these with e.g. polysilicones. In the Metropolitan Museum, the reaction products of sea spray with nitrogen oxides from traffic appeared to penetrate unexpectedly in some of the galleries and show cases. Improving the particle filtration system in these locations is the only option.

4. Conclusions

Although the atmospheric conditions in museums can now be assessed rather easily, also with respect to particles, urgent questions that are far from having been solved at this moment pertain to: (1) the modelling of the deposition processes from the atmosphere to the CH items, (2) the study of the critical surface interactions that take place on CH items composed of various materials and particular atmospheric particle types, e.g. in reaction chamber experiments, and (3) the establishment of suitable particle concentration standards.