Piezoelectric Dosimeters: a Tool for Assessing Microenvironments in Conservation Areas

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Abstract

This paper aims to describe and critically appraise the use of monitoring devices based on quartz microbalances developed for following the ageing of artistic materials that can be coated as thin films on quartz piezoelectric crystals. Data on the ageing rates occurring in the films during exposure in a conservation area are used to assess that specific microenvironment in terms of risk of damage for painted works of art. The simultaneous measurement of temperature, relative humidity and light intensity and type through on-board sensors is helpful to interpret the response of such piezoelectric dosimeters. Although to date no multivariate analysis has been attempted, these systems have potentials to be used in arrayed form and produce data for an overall indoor microenvironment assessment for preventive conservation.

Introduction

In the field of cultural heritage preservation, establishing and monitoring the aggressiveness of indoor microenvironments towards materials is an essential task for conservation professionals and represents an important step in the overall definition of environmental management strategies in museums [1]. In this context, over the last few years there have been increasing efforts towards the development of overall environmental dosimeters [2-3], or impact sensors, as monitoring tools. The idea is to focus directly on specimens of materials of interest and measure the actual physical and chemical stress inflicted by environmental factors under the specific microclimatic conditions of an indoor conservation area. In this way, the extent of changes in a property of the exposed material (or the rate at which they occur) could serve to establish the aggressiveness of the medium and provide an early warning of damage risk for the objects made of that material (or similar types of materials) which should result in positive actions on the part of the curators.

In particular, our group has proposed the use of automatic devices based on quartz microbalances for monitoring the ageing of artistic materials that can be coated as thin films on quartz piezoelectric crystals. Data on the ageing rates occurring in the films during exposure in a conservation area are used to appraise that specific microenvironment in terms of risk of damage for painted works of art. The response of piezoelectric dosimeters modified with a triterpenoid resin varnish (dammar) to accelerated photochemical ageing proved to be able to discriminate between different degrees of auto-oxidative stress [3]. Triterpenoid varnishes have been so far the privileged target materials, a simplified choice justified by their specific susceptibility to auto-oxidative degradation and to the attack of noxious airborne pollutants, such as NO_2. Still, the response of such systems is multiparametric and, in fact, the synergistic effect of other variables (such as relative humidity and temperature) should also be taken into account – as well as the differentiated action on different materials. Therefore we believe that they are a monitoring tool that could benefit from the use of chemometrics for optimised results.

Here, examples of real responses of the monitoring devices are shown in field campaigns carried out in two of the most important museums of the city of São Paulo, Brasil.

Materials & Methods

Piezoelectric dosimeters are made of 10-MHz A-cut quartz crystals (ICM-USA) modified with thin films of mastic varnish and used as resonant elements in oscillating circuits in dataloggers devices (each datalogger houses two modified quartz crystal). A microcontroller drives the oscillating circuits and reads and stores the oscillating frequency of the modified quartz crystal: due to autoxidative processes on the varnish film, the ageing of the material results in negative shifts of the oscillating frequency that are used to follow the ageing rate over time at a desired sampling rate. The monitoring campaigns were carried out during periods of seven weeks in exhibition and storage rooms in two museums of the city of São Paulo, Brazil.

Results

A typical result obtained in the comparative assessment of microenvironments in the two museums is shown in Fig. 1. The graph indicates that mastic varnish ages at a higher rate in the in the exhibition room than in the storage room (where mastic autoxidation takes place more rapidly than in an artificially chamber used as a control). Similar features are obtained in comparisons between areas with same function in different museums and with different levels environmental control. In exhibition areas, there is a good level of correlation between light intensity and ageing rate, but the role of temperature and relative humidity is still uncertain (as well as the contribution of the presence of air pollutants).

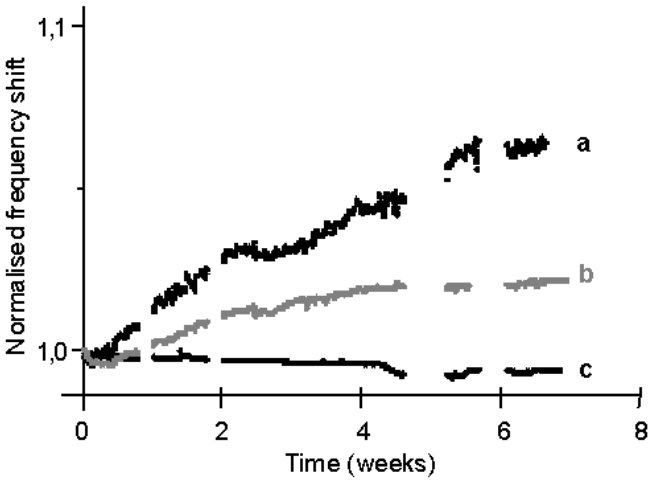

Fig.1 Response of piezoelectric dosimeter exposed in the Exhibition (a) and in the Storage Room (b) of the History Museum and in the Control Chamber (c)

Conclusions

The data so far collected indicate that mastic-modified piezoelectric dosimeters do show differences in microenvironmental characteristics, yet the response based on a single target material does not enable an overall assessment of the conservation areas and the influence of other environmental factors on complex objects like paintings. The possibility of unravelling the individual effects of every environmental factor involved in the ageing process is indeed one of the current limitations of the proposed system. The idea of trying and establishing this link is important for museum curators in order for them to make suitable decisions in terms of preventive conservation. The use of an array of crystals (as in electronic noses) is one of the possibilities to overcome this drawback and this, in turn, is likely to lead to the need of chemiometric tools for data treatment.

References

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