# Abstract
# Near infrared spectroscopy as a tool in cultural heritage conservation

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## Introduction

Cultural heritage is the foundation of every nation's identity and with the growing importance of tourism, it is also becoming a major economic factor, concerning the people employed in the industry, and as well, having a direct impact on the national income. However, the changing environment, rising tourist numbers, aggressive urban renewal, and non-optimal conservation practices impose a growing threat to the fragile remains of our past. Identification and characterisation of cultural heritage materials is of utmost importance for its preservation. Several methods exist for the purpose, but they are often unsuitable for analysis of precious artefacts. In this study, in order to faciliate the decisions of conservators in their treatment of artefacts, near infrared (NIR) spectroscopy has been examined as a possible method to determine the parameters that are associated with deterioration of paper and film materials.

## Materials and methods

Reflectance spectra were recorded using a LabSpec 5000 (Analytical Spectral Devices, USA). The spectrometer was fitted with probe 2 mm in diameter containing 37 fibres (200 micron core). NIR spectra were captured in the range 500–2400 nm, using 100 scans. Samples were analysed three or five times for films, or paper materials, respectively. Spectra were averaged before further analysis. We collected 211 newspaper and 130 film samples, which were then divided in two sets: one was used for calibration and the second one for validation. "The Unscrambler" software (CAMO, Oslo, Norway) was used for building the models. Principal Component Analysis was used for data reduction. Partial least squares regression was used to develop predictive models. Derivatisation (first derivative, Savitzky-Golay algorithm) and SNV was used for preprocessing to obtain the best model. The wavelength range was also optimised to obtain the best calibration. The models were calibrated against classical analytical methods. In case of paper, pH of the paper extract and an average molar mass of the carbanilated derivatives were determined (minimum measured value was 142,300 and the maximum 1,116,500), while A-D strips (Image Permanence

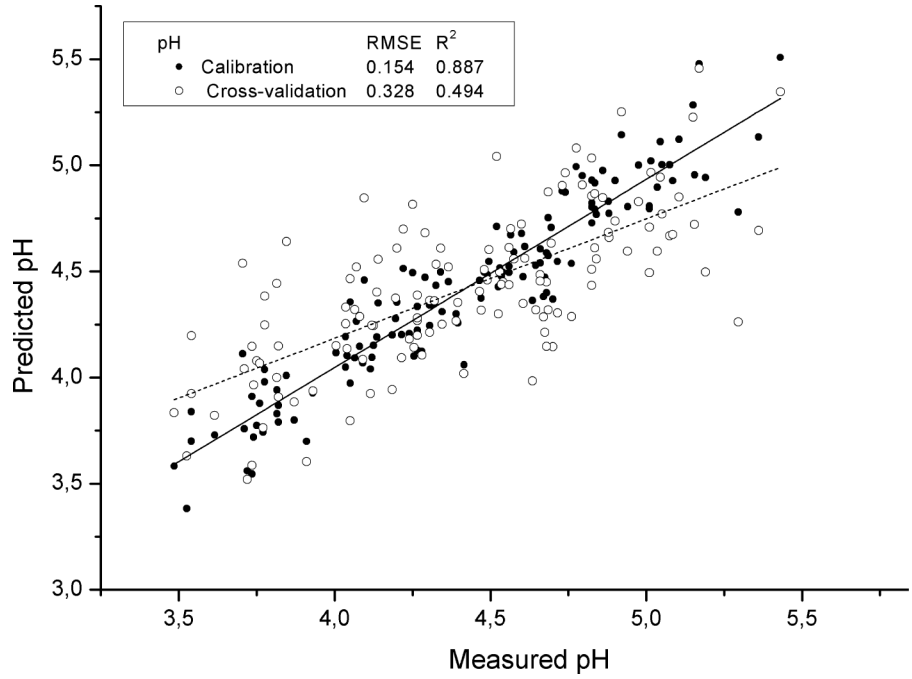


**Figure 1.** Calibration and validation plot for pH values.

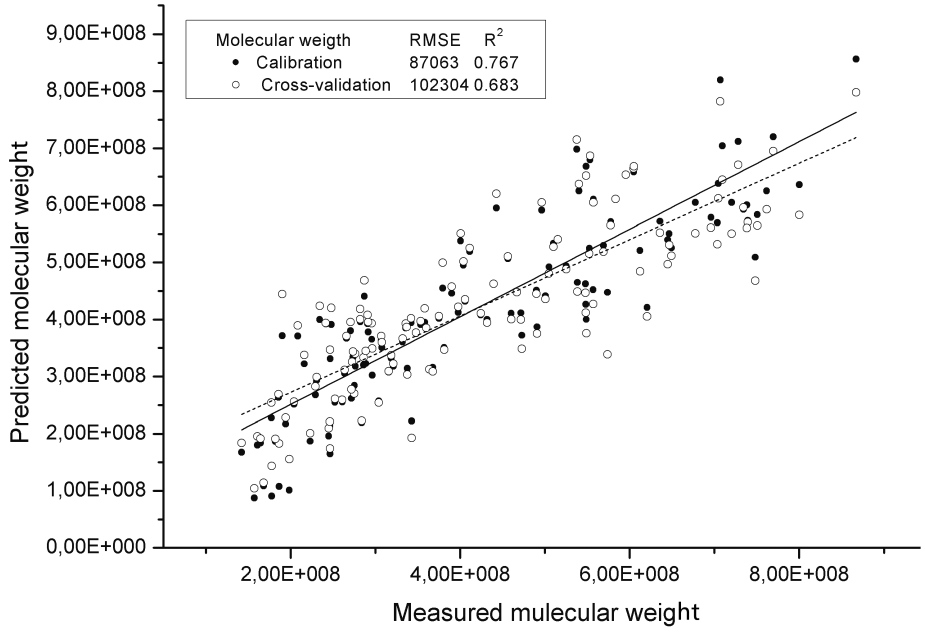


**Figure 2.** Calibration and validation plot for molecular weight values.

Institute, Rochester, NY) were used for characterisation of the condition of historical film materials.

A-D strips are paper-based indicators which use brom-cresol green, as a sodium salt, and are used to determine the severity of acetate film deterioration within film archives.

## Results and discussion

We obtained good correlations for pH (*RMSEC* 0.154) and Mw (*RMSEC* 87063) for paper samples (Figure 1 and 2) and less satisfactory in the case of correlations for AD strips measurements for films.

This was believed to be due to the fact that the A-D strip method is highly subjective. Also, it is a measure of the evolved gaseous acidic products, and does not directly relate to the actual condition of the material. This also explains the poorer quality of the correlation. Results are important for the preservation of cultural heritage, as the NIR methodology offers a facile, rapid and non-destructive characterisation of the multitude of properties related to the condition of materials. In addition, the NIR spectrometer used is portable and thus easily brought to the site of the collection.