Chemometric Processing of Infrared Spectral Data for Detection of Binding Medium in Safavid Persian Wall Paintings

Z. Haghighi[1], A. B. Garmarudi[2], A.H. Karimy[1]
[1]Faculty of Conservation, Art University of Isfahan, Isfahan, Iran
[2]Chemistry Department, Faculty of Science, IKIU, Qazvin, Iran

Abstract

Characterization of the binding media is a challenging problem in cultural heritage due to the restricted sampling, ageing of organic components and presence of complex materials in structure of wall paintings. Recently the application of infrared spectroscopy in cultural heritage scientific activities is an emerging topic. However, complicated situation of architectural samples and diversity of spectral data in the infrared region, approve the necessity for utilization of chemometrics data processing. The principal aim of this work is to evaluate the application of infrared spectroscopy in combination with chemometric pattern recognition data processing to identify wall painting's binding medium. To go through this purpose, a set of model samples were prepared in a similar approach to the strata of a real Persian wall painting from lowest to highest complexity. Sampling from the historic wall paintings of Sukias house was accomplished as well. Each sample was analyzed and SIMCA analysis was applied to the FTIR datasets. The obtained results have shown that the proposed method can be a useful tool for detecting complex architectural samples.

Introduction

The paint layer is mainly composed of pigments and organic binding media and other additives. Identification of binding medium in historical wall paintings is necessary for proper conservation activities. In addition it reveals paint technique and increases the knowledge about past used materials and customs. Based on chemical composition of the binding media employed in cultural heritage wall paintings, they are classified as protein materials, drying oils and carbohydrates [1]. Binding media's nature and their quantity, aging process, presence of interfering matrices of organic and inorganic ingredients in samples, and restricted sampling possibilities as well have caused the characterization of binding media in cultural heritage to be a severe challenge for researchers. FTIR spectroscopy has been employed to study art works in both the organic and inorganic materials [2]. Obviously, sample composition would provide a complicated spectrum in which the interpretation of spectral features for extraction of the valuable information is with ambiguity. However it offers huge set of data that is suitable to be processed in combination with chemometric pattern recognition data processing techniques.

Most historical Persian wall paintings are centered in Isfahan and have been created in Safavid period as decorative element in buildings and palaces. The case study of this research is Sukias house.

Materials & Methods

Materials used to construct the model samples were chosen basing on their widespread application through Persian history, in particular during Shah Abbas II period, and according to studying the historical documents and prior researches [3]. In this research we used red ochre, ultramarine blue, lead white, indigo and chalk as pigments and linseed oil, Arabic gum, egg yolk as binding media and gypsum and animal glue as ingredients preparatory layer. Two sets of standard samples were prepared on glass slides. The first set composed of single materials and the second simulating the strata of a real Persian wall painting from lowest to highest complexity. Totally 56 samples were prepared. The Sampling from Sukias house was accomplished from red, blue and white

colors. Each sample was analyzed by FTIR spectroscopy and spectral data set was processed by SIMCA, after some preprocessing and PCA.

Results

FTIR data were baseline corrected and mean centred. Then SIMCA applied to standard samples dataset in two step of calibration and prediction. In the first step 41 samples were used to build the calibration model and the remaining 15 samples were used as prediction set. In calibration step, at first 8 PCs were selected which could reflect 95% of the total variance. It should be mentioned that whole spectral region were selected. As presented in Fig.1 there is one outlier in both SIMCA models of linseed oil and Arabic gum classes. In validation step, out of 15 samples, 6 samples were from Arabic gum class, 3 samples from egg yolk class and 6 samples from linseed oil class. In case of the samples of Arabic gum class, two samples were misclassified in egg yolk class but the other samples were positioned in their own classes. Architectural real samples were then projected to the SIMCA model to be classified. In case of samples from Sukias house all of three samples from three different colours were predicted as egg yolk class

Conclusions

According to the results obtained, chemometric pattern recognition techniques could classify complex samples mostly and it could be used as a useful tool for researches with such purposes.

References

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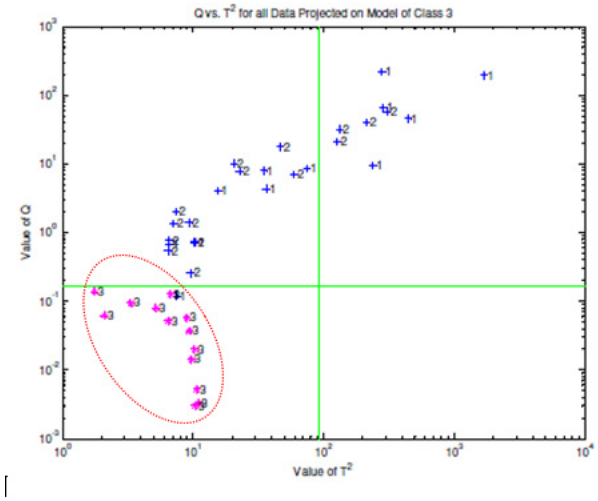
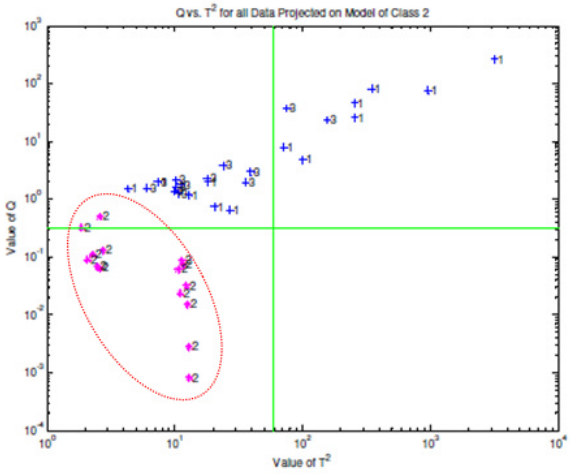


(A)



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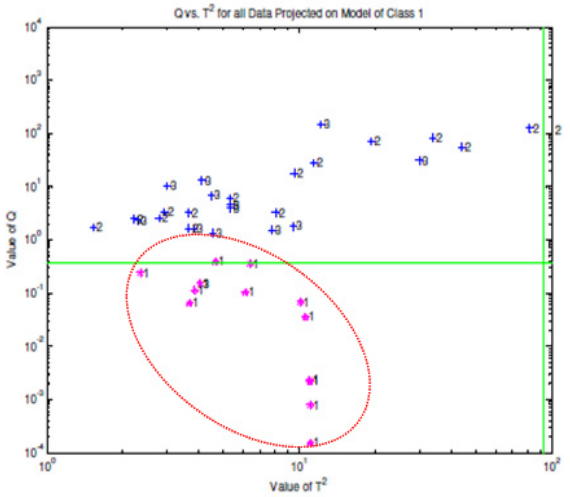

(C)

Fig. 1, SIMCA calibration step, Q verses T^2 for three classes of Arabic gum (A), egg yolk (B) and linseed oil (C)