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Novel approach of signal normalization for depth profile of cultural heritage materials

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Abstract
The investigation of cultural heritage materials is always complex and specific because unique. Materials are most often heterogeneous and organized in several layers such as mural paintings or corrosion products. The characterization of a complete artwork's stratigraphy is actually one of the questions of science conservation. Indeed, the knowledge of these layers allows completing the history of the work of art and a better understanding of alteration processes in order to set up an appropriate conservation action. The LIBS technique has been employed to study the stratigraphy of an artwork thanks to the ablation laser.
However, as we know, atomic information could be insufficient to characterize two materials composed by the same based elements. Therefore, an additional molecular analysis, like Raman spectroscopy; is sometimes necessary for a better identification of the material in particular for organic coatings in cultural heritage. We suggest in this study to use Standard Normal Variate (SNV) as a common normalization for different kinds of spectra (LIBS and Raman spectroscopy) combined with a 3D colour representation for stratigraphic identification of the different layers composing the complex material from artwork. So in this investigation, the SNV method will be applied on LIBS and Raman spectra but also on baseline Raman spectra often considering as nuisance. The aim of this study is to demonstrate the versatility of SNV applied on varied spectra like LIBS, Raman spectra as well as the luminescence background.
This original work considers the SNV with a 3D colour representation as a probable new perspective for an easy recognition of a structure layered with a direct overview of the depth profile of the artwork.

Keywords :SNV ; cultural heritage ; stratigraphy ; Raman ; LIBS ; luminescence background

1. Introduction

Each piece of artwork is the result of a wide variety of human and environmental influences. It is considered as information concentrated in the material. So the knowledge of its physic-chemical state could be an exploration source for answering cultural-historical questions that cannot be solved by stylistic and art-historical examination alone. To perform this task, analytical instruments are used and provide a quantitative or qualitative analysis, elemental or molecular, on surface or in depth of the sample. The latter is actually one of the questions of science conservation. Indeed, materials from cultural heritage are often organized in several layers such as mural paintings or corrosion products. Several analytical methods are employed to study the sample's stratigraphy, especially techniques based on spectroscopy. EDS (Energy Dispersive Spectroscopy) generally coupled with SEM (Scanning Electron Microscopy) uses X-ray excitation and is a very common technique for elementary analyses of historic artifacts [1-4].

However it requires sampling and preparation. On the contrary LIBS could avoid these two last drawbacks by in situ analyses, ensuring also multi-elemental analyses with laser excitation.

Nonetheless cultural heritage is often composed of complex materials where atomic information could be insufficient for characterization especially for materials with the same elemental composition like corrosion products. Therefore, a molecular analysis could be performed with common vibrational spectroscopies like Raman to improve the material's identification. This technique has already proved its utility in analyzing artwork [5-8].
However, the main drawback on Raman's spectroscopy is the weak Raman signal usually dominated by the luminescence background [9-12]. The latter is often considered as an inconvenience which could reduce the signal to noise ratio, this is why the scientific community has always tried to remove it [14, 15]. The main reason of this phenomenon is the nature of the material. So the luminescence background could also be