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Analysis of cultural heritage by synchrotron radiation and visible light-near infrared spectroscopy

Jay Arre Toque, Ryoichi Nishimura, Ari Ide-Ektessabi*
Advanced Imaging Technology Laboratory, Graduate School of Engineering, Kyoto University, Yoshida-Honmachi, Sakyo-ku, 606-8501, Kyoto, Japan

Introduction

Cultural heritage refers to artifacts and intangible features inherited from previous generations, which are preserved or maintained for the benefit of future generations. In the past, interests in cultural heritage are mainly based on its aesthetic and historic values. However during the recent years, it has been attracting the attention of scientists and engineers because of the technical challenges it presents during analysis, restoration and preservation. Its delicate nature requires that the investigation should be non-destructive and non-invasive. Among the available analytical techniques, synchrotron radiation-based analysis offers high precision and high accuracy in addition to being non-destructive [1]. On the other hand, a technique utilizing visible light and near infrared radiation is able to complement the insufficiencies of high-energy techniques. Synchrotron radiation (SR) and visible light-near infrared spectroscopy (VL-NIS) were used to study some important aspects of cultural heritage analysis.

Experimental

Synchrotron radiation was used to investigate the relationship between fine structural change and color fading in natural mineral, specifically azurite [2]. Ten samples of azurite pigments were heated at 260°C with holding time from 10 minutes up to 90 minutes with 10-minute increment. The spectral reflectance of the heated and unheated pigments was measured to track the changes in color. X-ray fluorescence and X-ray absorption fine structure (XAFS) were used to characterize the pigments. The incident X-ray was 15 keV for XRF analysis while the energy was scanned at the Cu K absorption edge from 8.90 to 9.09 keV for XAFS. The discoloration due to heating was also studied using VL-NIS.

Results and Discussion

Fig.1 shows the spectral reflectance as a function of heating time along with its corresponding SRXRF and XAFS spectra. The pigments predictably changed its color upon heating. It is interesting to note however that the discoloration did not change the position of the spectral peak. The samples got darker with the increase in heating time. In order to understand the mechanism of discoloration of the pigments when subjected to elevated temperature, the pigments were also analyzed by synchrotron XRF and XAFS analysis. The XRF spectra show minimal change. This implies that the color change was not due to the trace elements of the pigments. The trace elements of the burnt and unburned pigments are similar but their colors are quite different. The changes in color of both the pigments may be more attributed to the change in chemical bonding state of the main element Cu. It was found that the absorption edge of the samples heated for 80 and 90 minutes shifted to lower energy level.

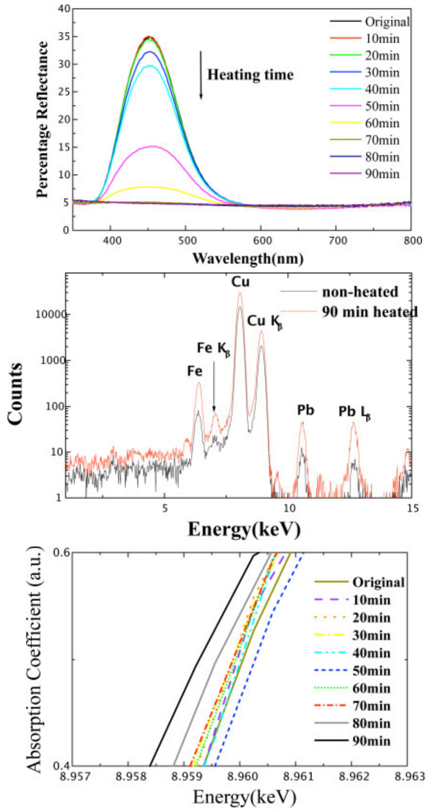

Fig.1: (a) Spectral reflectance of azurite as a function of heating time; (b) SRXRF spectra; (c) XAFS spectra.

References

[1] Ari Ide-Ektessabi. Applications of Synchrotron Radiation. Springer- Verlag Berlin Heidelberg 2007.
[2] Ryoichi Nishimura and Ari Ide-Ektessabi. The relation between the fine structural change and color fading in the natural mineral pigments Azurite and Malachite. MRS 2007 Fall Meeting, Boston, USA, November 2007.

* h51167@sakura.kudpc.kyoto-u.ac.jp