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Application of ionoluminescence spectroscopy for the provenance study of historical ceramics: The preliminarily results

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Abstract

The ionoluminescence spectroscopy, as an appropriate technique for the investigation of cultural heritage objects, is suggested to be also applied for their provenance study. To support the idea, the ionoluminescence spectra of the clays of two different historical luster glazed ceramics of the same origion were collected and compared with each other. It was shown that despite the high sensitivity of the ionoluminescence technique, the configurations of the spectra and their constituting bands were very similar to each other. Therefore, ionoluminescence spectroscopy could be considered a promising technique for the provenance study of historical ceramics and other cultural heritage objects.

Keywords: Ionoluminescence Spectroscopy; luster glazed ceramics; provenance study

Introduction

Ionoluminescence (IL) spectroscopy is a highly sensitive, non-destructive and fast technique that provides structural and elemental information of the luminescent samples [1]. It could be applied as a complementary technique to the more common ion beam analysis (IBA) techniques, such as particle-induced x-ray emission (PIXE) and Rutherford backscattering spectrometry (RBS), using the same facility, to extract comprehensive information from the sample. Over the last two decades, the results of the application of IL for some cultural heritage (CH) investigations have been reported [2,3]. However, its capabilities for the CH studies haven't been fully recognized.

Provenance study of CH objects is one of the most important fields of studies in CH which provide valuable information regarding the origin of the objects, the historical trade routes, the relations between different nations, their industrial developments, etc. In this regard, different elemental, isotopical and structural-based techniques have been employed to distinguish CH objects of different origins. However, in some cases their differentiation is not a straightforward task, therefore, more innovative techniques should be employed. Considering its high sensitivity, IL spectroscopy could be a suitable technique for the provenance study of CH objects which, to the best of our knowledge, has never been used for this purpose.

In this research work, the IL spectroscopy technique has been applied on the clay parts of two different pieces of luster glazed ceramics of the same origion [2] to examine its capability for provenence studies.

Experimental

Preparation of the materials

Two different pieces of luster glazed ceramics (Fig. 1), discovered from the historical (12th-13th century) cite of Tappeh Ghale, Khomein, which have been produced in Kashan, Iran, were selected for this study. Considering different appearences of the samples C1 and C2, the elemental and structural characteristics of their glazed surfaces are different from each other [2]. Therefore, the clay parts of the samples, with almost the same appearences, were examined by the IL technique.

The experiments were performed at the Van de Graaff laboratory of Tehran. The in-air setup of IL [2] was used to perform the experiments, with a spectrometer of 1.4 nm resolution. A proton beam of 2 MeV energy and a current of ~ 4 nA was applied to irradiate the samples. The IL spectra of the clay parts of the samples were collected within 20 seconds.

Figure 1. The studied luster glazed ceramics denoted as C1 and C2. The clay parts of the samples were investigated.

Results and discussion

It is known that the studied samples are from the same origion, therefore it is expected to obtain similar IL

spectra for them. It should be mentioned that since the sensitivity of IL is on the order of 1 ppm, the slightest elemental or structural differences between the clays affect their spectra. The IL spectra of the clays are shown in Fig. 2. It can be observed that, as it was expected, the IL spectra of both samples present the same configuration with the same peak positions. The sharp peak in the spectrum of C1 is due to the noise sources. The geometry of the experiments was not fixed, so the intensities of the spectra are not comparable. In order to distinguish the bands forming these spectra and to compare them more precisely, the spectra were deconvoluted.

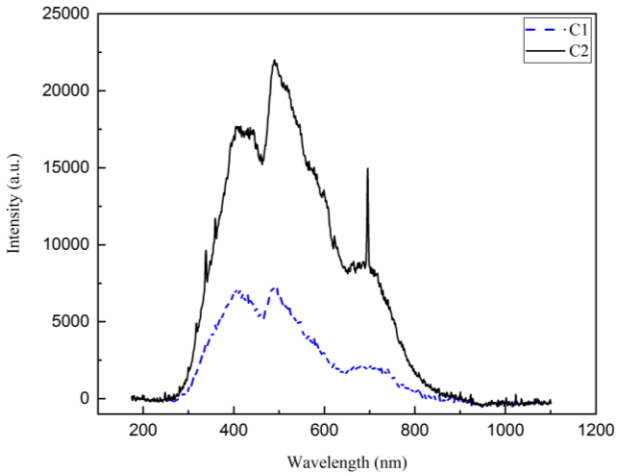

Figure 2. The IL spectra of the clay parts of the C1 and C2 samples.

The results of the deconvolution of the IL spectra of samples C1 and C2 are shown in Fig. 3. The noises were removed by the Fast Fourier Transform (FFT) filter. The IL bands of C1 are located at 1.76, 2.45, 2.53, 2.80, 3.02 and 3.50 eV, and the IL bands of sample C2 are located at 1.76, 2.37, 2.53, 2.80, 3.02 and 3.39 eV. Both spectra were deconvoluted into five bands, which three of them are exactly located at the same positions. There are minor differences between the positions of the two remaining corresponding bands, i.e, 0.08 and 0.11 eV. Moreover, it can be seen that the bandwidths of the corresponding IL bands in the two spectra are almost equal. The results approve the unique origion of the two samples, although they may not have been produced exactly at the same time. In other words, the materials used for producing the clays of the two samples, and also their formation process are generally similar, but not exactly the same. Therefore, slight shifts in some IL bands and also differences between relative intensities of the bands are observed. It should be noted that regarding the high sensitivity of IL, which detects the slightest differences between samples, it rarely exhibits similar spectra for two different samples. Therefore, observation of such similarity between the IL spectra of the two samples of the same origion, is very promising.

Conclusions

Regarding the characteristics of the IL spectroscopy techniques, it is an appropriate technique that can be applied for non-destructive and fast characterization of valuable CH objects. In this research work, it was suggested to apply this technique for the provenance study of the CH objects. In this regard, the approving results of this study support the idea. Therefore, more experimental investigations should be performed in this field to figure out what types of CH objects are suitable for such investigations and also distinguish their provenance quickly.

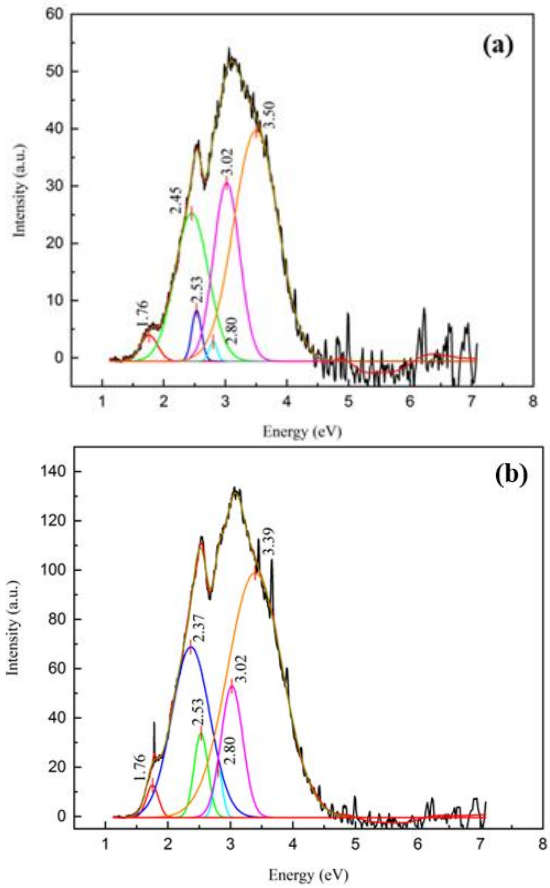

Figure 3. The results of deconvolution of the IL spectra of the samples C1 (a) and C2 (b). The bands' positions are remarked.

Acknowledgments

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