SEM Study on Old-styled Thai Gold Mosaic Glass Samples

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Gold Mosaic glass has been used to decorate items and places since ancient time. The glass structure is divided into three layers: cover glass, gold layer and glass substrate. In this study, the composition of old-styled Thai gold mosaic glass samples was analyzed using SEM/EDX and Raman spectroscopy. It was found that the glass composition was sodium-silicate based glass. Raman spectroscopy also showed the confirmation of the different chemical compositions of the old-styled Thai gold mosaic glass layers.

Keywords old-styled Thai glass; gold mosaic glass; SEM/EDX; Raman spectroscopy

1. Introduction

For centuries, gold has been used to decorate on glasses and ceramics, such as, tableware, ornament objects and mosaics [1]. Mosaic is an art form of fitting together pieces of stones, glasses, glaze tiles, etc., to create a pattern on plain surfaces [2]. Various colored glass mosaics were made less transparent than normal glasses by an addition of coloring and/or opacifying agents [3-6]. In the past, mosaics were used mostly in artwork. Gold mosaic glass is one of the most precious mosaics since ancient times. It was first seen in Spain and Greece before spreading to the whole Mediterranean [1-7]. Gold mosaic glass was fabricated using gold-foil coating, one of the most ancient and remarkable techniques practiced during the Roman period where a gold foil is placed between two layers of glasses. Today, thin gold coating glasses are used in several technological applications requiring high electrical conductivity, high corrosion and oxidation resistance and high reflectivity [1]. In Thailand, the gold mosaic glass imported from European countries has been used to renovate old Buddhist sites, such as temples and sanctuary. The original glass keeps degrading overtime; thus restoration works are of urgent necessity. As a result, understanding the glass’ chemical composition and phase constitution is a must in conservation and restoration processes.

Modern techniques for materials characterization are of increasing usage in the area of archaeological materials science, especially, the application of electron probe microanalysis (EPMA) together with electron microscopy and x-ray microanalysis, and Raman spectroscopy to characterize microstructures of glass mosaics and materials used in the early glass production [3, 8-13]. Although the study of Ancient Thai Glass samples using scanning electron microscopy (SEM) and X-ray fluorescence spectroscopy (XRF) has been done [14], In this study, SEM/EDX was used for the first time to characterize microstructures of gold mosaic glass samples collected from a Buddhist sanctuary in Bangkok, Thailand. In addition, Raman spectroscopic technique was also performed for the first time on this kind of samples.

2. Materials and methods

The old-styled Thai gold mosaic glass samples to be studied were flat, small fragments of about 2 mm thick. Nikon Optophot 2-POL optical stereo microscope was used to study the macrostructure of these samples. Microstructural investigation of the gold mosaic glass samples were carried out using scanning electron microscope; Jeol JSM-5910, operated at 15.0 keV, coupled with energy dispersive X-ray fluorescence spectrometer; Oxford Instrument INCAx-sight, Si(Li) detector. Samples were coated with a thin layer of carbon prior to observation. Renishaw inVia Raman spectroscope was used to analyze the fingerprints of the old-styled Thai gold mosaic glass.

3. Results and discussion

Using optical microscope resulted the glass structure is divided into three layers, i.e., cover glass, gold layer, and glass substrate (Fig. 1). The glass-gold interfaces are of primary interest. From SEM/EDX revealed that the main compositions of the glass substrate were Si, Na, and Ca, whiles Si, Na, Ca and Al were the main composition of the cover glass. Aluminium (Al) added in the composition of the cover glass to obtain special properties, such as low thermal expansion and chemical resistant.
Fig. 1 Structure of the old-styled Thai gold mosaic glass sample; (a) Optical stereo microscope, (b) Scanning electron microscope

Table 1 Detectable elements and chemical composition of the glass sample

<table>
<thead>
<tr>
<th>Element</th>
<th>Composition (wt%)</th>
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<tbody>
<tr>
<td></td>
<td>Cover glass</td>
</tr>
<tr>
<td>Na</td>
<td>11.73</td>
</tr>
<tr>
<td>Si</td>
<td>34.59</td>
</tr>
<tr>
<td>Ca</td>
<td>6.32</td>
</tr>
<tr>
<td>Al</td>
<td>2.64</td>
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<td>O</td>
<td>44.72</td>
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Fig. 2 Raman fingerprints of the old-styled Thai gold mosaic glass samples

Different chemical compositions of the old-styled Thai gold mosaic glass layers were confirmed by Raman signature spectra, as shown in Fig. 2.

4. Conclusions

It can be concluded that the old-styled Thai gold mosaic glass was mainly composed of sodium silicate. Scanning electron microscopy, X-ray fluorescence spectroscopy and Raman spectroscopy are non-destructive methods suitable to characterize the glass structure and can be applied successfully in the field of archaeology.

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References