



Complementary analytical methods in identifying gilding and painting techniques of ancient clay-based polychromic sculptures



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ABSTRACT

The gilding and painting techniques for the clay-based polychromic sculptures in Jizo Hall of Chongqing Temple, Shanxi Province of China, are analyzed by complementary techniques of microscopy, environmental scanning electron microscopy (ESEM), energy dispersive X-ray mapping (EDX), micro-Raman spectroscopy (μ -RS), and Fourier transform infrared spectroscopy (FTIR) with a reasonable sequence. 7 gilded samples and 6 pigmented samples are collected from Jizo Hall. For the 7 gilded polychromic samples, drying oil-based, Chinese lacquer-based and glue-based “Jin Jiao” techniques are identified respectively according to their different adhesive layers used for jointing gold leaf to the preparation layer. But the presence of a copper foil top surface, as well as the inner layers with crocoites (PbCrO_4) and modern red pigment in one alleged gilded polychromic sample indicate a later restoration work. Among them, two gold layers have been identified in 4 samples due to the regilded work in history. For 6 pigmented samples, painting layer is generally applied on a white preparation layer made of kaolinite or the mixture of kaolinite and gypsum. Atacamite, cinnabar, minium, yellow ochre and gypsum are identified as the main pigments, and the protein-based material is confirmed as the binding medium for red pigments. This research not only reveals the Chinese traditional gilding and painting techniques employed in polychromic sculptures of Jizo Hall, but also demonstrates the advantages and limitations of each analytical technique for identifying polychromic samples, and the necessity of complementary analytical techniques approach.

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1. Introduction

Chongqing Temple is located at the Changzi County, Shanxi Province of China. It was first constructed in 1016 A.D. during the Northern Song Dynasty, and now is listed into the national emphasis cultural relics owing to its special Chinese architecture and art treasures of sculptures. There are five halls, including Thousand-Buddha Hall, Arhat Hall, Jizo Hall, Heaven King Hall and Reclining Buddha Hall, accompanied by plenty of polychromic sculptures in Chongqing temple. Jizo Hall is an important hall of this temple for its gilded and pigmented sculptures. There are 17 main polychromic sculptures in Jizo Hall, including the sitting sculpture of Bodhisattva Jizo at middle of the north wall, ten Yama sculptures and six diaconal god sculptures, and a lot of smaller artistic sculptures on the west, north and east walls. All the sculptures in Jizo Hall have constituted some special scenes in the hell from Chinese historical legends, such as the terrace in hell from which the dead can see their homes, the gate of hell as so on. On the whole, the layout of Jizo Hall has shown a typical pattern of “Ten Yama worship Bodhisattva Jizo”.

All the polychromic sculptures in Jizo Hall are clay-based and can be divided into gilded and pigmented sculptures. Generally, clay-based sculpture is made by the following steps: create the skeleton for each sculpture by making a timber framing according to its general shape; wind or bind straw rope around the frame to prepare a rough surface for applying clay layer; apply the clay + fiber mixture on straw rope and knead into the desired shape of sculpture, this kind of mixture is generally used owing to its strong and stable mechanical property; thoroughly dry the clay-sculpture in shade to avoid the generation of any crackle; apply preparation layer and painting layer on the dried clay-sculpture. Clay-based sculptures in ancient China are mainly decorated with mineral pigments at first, but the gild-decorated sculptures became very popular after Song Dynasty (960–1279 A.D.), especially in temples for Buddha sculptures by applying a very thin gold layer on the surface to manifest the artworks, just like an old Chinese saying “Clothes to people, Gold to Buddha”. Actually, gilding decoration is mainly applied on the exposed skin and cassock to present the Buddha's magnificence, splendor and solemnity. Some gilding is also applied on the little area of accessories, such as the crest, collar, tassel or scarf, to highlight the wrinkles or shadows in clothes, or to set off the original green, red, or blue color to get a gorgeous effect.

For the investigation of techniques and raw materials used in ancient polychromic artworks, the application of modern analytical ideas and

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methods could provide detailed and comprehensive information [1,2]. Up to now, many kinds of techniques and methods have been developed and successfully employed for the scientific investigation of ancient polychrome, such as the surface or cross-section observation with microscopy [3,4] and scanning electron microscopy (SEM) [5–7]; optical properties investigation of pigments with polarized light microscopy (PLM) [8]; mineralogical characterization of materials with X-ray diffraction (XRD) [9,10]; elements identification of materials with particle induced X-ray emission spectroscopy (PIXE) [9,11], X-ray fluorescence (XRF) [12–14] and energy dispersive X-ray detector (EDX) [15–17]; components identification with Fourier transform infrared spectroscopy (FTIR) [18,19] and Raman spectroscopy (RS) [5–7]. Since complex materials and structural layers are often applied in polychromic relics, no analytical technique alone would even close to solve all the problems, and therefore analytical protocols based on the combined use of different techniques become important and necessary for the scientific analysis of polychromic relics.

This paper presents the combination use of microscopy, ESEM–EDX, μ -RS and FTIR methods for analyzing polychromic samples collected from the Jizo Hall of Chongqing Temple. These techniques are selected based on that microscopic observations of cross-sections for sample under visible light could provide the color and thickness information

of each polychromic layer, while UV light observations could reveal the presence of organic binders through fluorescence [20,21]; environmental scanning electron microscopy coupled with energy-dispersive X-ray (ESEM–EDX) analysis is proved to give the morphology information and elemental compositions of tested area at micro- or even sub-microscale without coating the sample surface with conducting material [22,23]; micro-Raman spectroscopy (μ -RS) as an ideal tool could identify the mineral pigments because of its high spatial resolution ($\leq 5 \mu\text{m} \times 5 \mu\text{m}$), non-destruction and essentially be immune to interference from both pigments and binders [24]; FTIR is powerful on distinguishing organic binding media and/or inorganic materials [25]. Therefore, consecutive utilization of these analytical techniques can elucidate the morphology and chemical composition of each paint layer allowing a full characterization of polychromic artworks.

The aim of this paper is to investigate the gilding and painting techniques used in the Jizo Hall of Chongqing Temple. Thirteen samples are analyzed by microscopy, ESEM–EDX, μ -RS and FTIR with a reasonable sequence to identify the raw materials of pigments and binders in order to further deduce the gilding and painting techniques. The research results would be useful not only to assist in the authenticity of used materials in the analyzed polychromic samples, but also to deeply understand the techniques, especially the Chinese traditional gilding techniques.



Fig. 1. Landscape of Chongqing Temple (a), photo for the sculpture of Bodhisattva Jizo (b), sculpture group at the west wall (c), and sculptures of Yama on at the west wall (d, e, f, g).

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