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Characterization of grounds, pigments, binding media, and varnish coating of the Angel Michael' icon, 18th century, Egypt

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ABSTRACT

Samples from canvas, grounds, pigments, and varnish coating from the icon of Angel Michael came back to the 18th century from the church of Samanod, Gharbeia Governorate, Egypt, were investigated using multispectral signals of SEM-EDX, FT-IR, and Mass spectrometry. The SEM data from the canvas indicated that it is of linen. EDX of the grounds indicated that they are of gypsum with natural impurities of halite, quartz, and clay minerals. FT-IR spectra of the grounds indicated that the binding medium was of animal glue where gypsum was mixed with animal glue. The SEM-EDX pattern of the orange pigment showed the presence of lead, minium (Pb_3O_4) is the most probable, the blue color was Egyptian blue, whereas tetrahyrate [$(Cu, Fe, Zn, Ag)_{12}Sb_4S_{18}$)] may be used as a source of copper and crushed limestone was used as a source of flux. The gold color is composed red lead mixed with titanium oxide. The icon paintings were coated with a resinous layer of dammar, which had darkened into a brown color by photoxidation.

1. Introduction

There are some well-known Coptic icons from the sixth- and seventh-century in Egypt, but time by time they were exposed to destruction (Tribe, 2004). From the 17th century onwards, local authorities allowed the Copts to renovate old churches and to build new ones; also, old manuscripts were being copied and new ones were created after the destroying and burning of old icons movements prevailed in the 14th–15th centuries following the old Christian religious and artistic traditions (Török, 2005; Nugteren, 2011). Furthermore, in the second half of the 18th century a resurgence of icon painting took place and many of these icons were painted by Ibrahim Al-Nasekh and Yuhanna Al-Armani, who signed many of these renovated icons (Tribe, 2004; Abdel-Ghani et al., 2009; Nugteren, 2011).

The anatomy of a typical icon in general is composed of five layers: wooden panel, linen canvas, ground layers, painting layers and varnish layer (DeVasilescu, 2010; Hayashi, 2009).

1.1. Wooden panel

Wooden panel was used as support for other components of icons and often being of local and available wood, in particular sycamore wood, the most common occurred in Egypt (Lucas, 1948).

1.2. Linen canvas

Icons are painted on panels of wood, glass and other materials or, in rare cases they were carved either in wood or ivory (DeVasilescu, 2010), but from the beginning of the Christian age in Egypt painters used linen cloths representing iconic religious subjects. In general, the canvas was made of linen, the most available and cheap textile and has suitable roughness to adhere to the wooden substrate panel (Miles, 1956).

1.3. Ground layers

Ground layer is applied on the support to conceal irregularities in the support such as pores, holes and wood grain and to provide a smooth painting surface with the desired color, texture and porosity and for egg tempera. This layer is a mixture of some form of whitening; in this research gypsum ($CaSO_4 \cdot 2H_2O$) was used, being the most popular material for icons, with egg yolk as the predominant binding medium or animal glue (Hayashi, 2009) and in some cases a high portion of calcium carbonate was added intentionally to the ground layers to increase the

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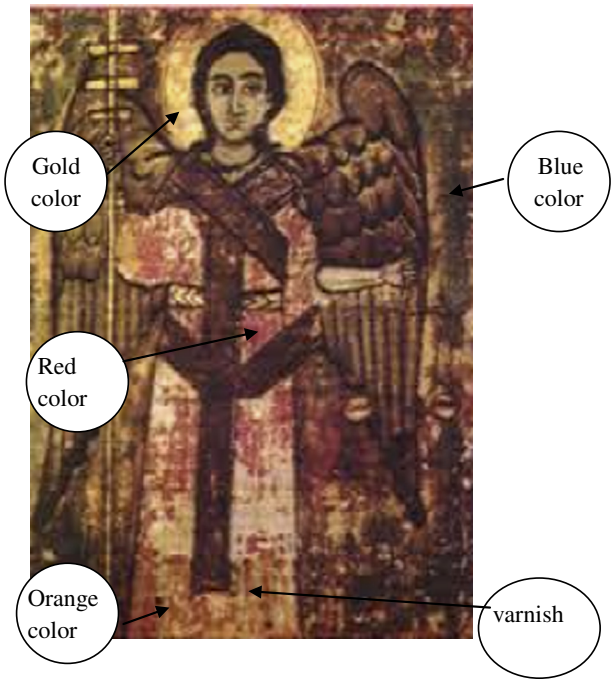

Fig. 1. Sampling locations of the icon of the Angel Michael, 18th century.

Table 1
Colors, its locations within the icon and its identification.

Color	Location	Identification	Reference
Gold	Wings of the angel	Titanium oxide and limonite	Burgio et al. (2003)
Red	Cloak of the angel	Red lead (minium, lead oxide Pb_3O_4)	Daniilia and Minopoulou (2009)
Orange	Garment of the angel	Lead (litharge [α-PbO] (lead monoxide)	Walton and Trentelman (2009)
Blue	Ground of the icon	Egyptian blue (copper calcium tetrasilicate, $CaCuSi_4O_{10}$)	Hatton et al. (2008)
Brown spots within the red color in the garment of the Angel		Galena (PbS)	Sakr et al. (2015)
	Clothes under the ground	Linen	Abdel-Ghani et al. (2009)
	Wooden support	Sycamore	Abdel-Ghani et al. (2009)

brightness of gypsum (Garcia-Guinea et al., 2008), but gypsum, the ground of icons and the gesso layers contain impurities such as clay minerals, quartz, and organic matters (Abe et al., 2009; Scott et al., 2009; Ronca, 1994).

1.4. Painting layers

1.4.1. Red lead

The palettes of painters in this period varied greatly because of the increased availability of pigments. The most common red pigment in this period was red lead (Pb_3O_4), widely used in a large variety of works such as manuscripts and canvas paintings (Aze et al., 2008).

On the other hand, it seems that in Egypt red lead was used only from Greece-Roman times and later became the favorite pigment of Persian and Byzantine illuminators (Aze et al., 2008).

1.4.2. Orange color

The color of lead oxides vary according to their chemical composition, since litharge [α-PbO] (lead monoxide) is an orange pigment, massicot is yellow and minium (lead oxide Pb_3O_4) was used as a red pigment (Walton and Trentelman, 2009).

1.4.3. Gold Color

Gold color sometimes was obtained by mixing red lead with white oxide such as titanium oxide. The previous studies on the gold color commonly used in Florence during the 14th century and in Venice and Bohemia during the 16th century have indicated the presence yellow color of lead tin (Borgia et al., 2007).

1.4.4. Egyptian blue

Egyptian blue is the oldest known synthetic pigment, invented by the Egyptians since the first dynasty, but from the Fourth Dynasty (2613–2494 BC) it was widely used in tombs and temples in Egypt (Jaksch et al., 1983), and its utilization extended till 19th century AD (Bredal-Jørgensen et al., 2011), but in the 16–18th centuries, the Egyptian blue replaced the azurite blue, this may be ascribed to its poor quality and impermanence as a blue pigment (Abdel-Ghani et al., 2009, 2012).

Egyptian blue is multi-component composed mainly of calcium-copper tetrasilicate (cuprorivaite $CaCuSi_4O_{10}$), presents large, transparent, glassy, blue-greenish crystals which are moderately pleochroic and with bright interference colors (Canti and Heathcote, 2002). This pigment was prepared by heating a mixture of sand (or calcareous sand), copper compounds (copper ores or bronze scraps) with an alkaline flux either of crushed limestone, natron or plant ash in a muffle furnace

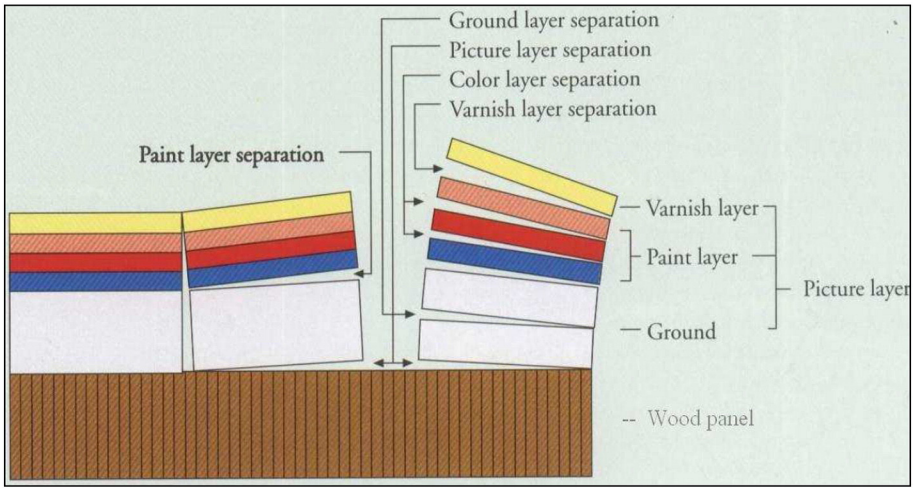

Fig. 2. Analytical Structure of the icon composition pointed out that icons are composed of fives layer.