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On the study of oil paint adhesion on optically transparent glass: Conservation of reverse paintings on glass

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ABSTRACT

Reverse painting on glass is a technique which consists of applying a cold paint layer on the reverse-side of glass. The main challenge facing these artworks is the fragile adhesion of the pictorial layer – a simple movement can modify the appearance of the painting. This paper details a study into the adhesion parameters of pigments on glass and the comparison between different pigments. The relationships between the binder (linseed oil) with pigments and the glass with or without the use of an adhesive are studied. Physical analyses by surface characterisation have been carried out to better understand the influence of the pigment. The use of a sessile drop device, optical microscopy, scanning electron microscopy (SEM), a surface 3D profiler and a pencil hardness scratch tester were necessary to establish a comparison of the pictorial layer adhesion. A comparison of the effect of two adhesives, namely ox gall and gum arabic, has shown that the adhesion is not only linked to the physical parameters but that possible chemical reactions can influence the results. Finally, a treatment based on humidity-extreme storage has shown the weakness of some pictorial layers.

1. Introduction

In the art of painting, many kinds of support can be used. For example, wood, canvas and stone have all been utilised in the past. One other such support is glass. Glass has been used and manufactured since Antiquity and is produced by melting a mixture of silica with alkaline and a stabiliser. The evolution of the composition of glass has led to optically transparent glass which has contributed to the development of various painting techniques [1]. From this, two techniques have arisen: fired paintings and cold paintings. In the case of fired paintings, the pigments are applied on the surface of glass with a vitreous material and then fired until the melting temperature is reached to fix the decoration [2]. Cold painting on glass has been conducted since the Roman era by applying lacquer and oil paint on to the glass surface. Due to the speed of deterioration from oxidative processes and the effects of humidity, the technique of reverse painting on glass has been further developed over time with the glass being utilised, simultaneously, as a protective varnish and a support. These paintings are directly executed on to the back of the glass in a reverse manner. That is, first, the details and shadows are painted and then the background. The different colours can be applied one after the other, once the previous layer has dried, or can even be applied before drying by implementing thinner layers [3–5]. The presence of a black background (e.g. paper, wood) is necessary on account of the optical nature of the reverse paintings as they are viewed using reflected light rather than the traditional transmitted light. Having said that, some glass paintings have been used as a filter in front of projected light but this has only been seen in special cases [1]. One of the unique features of reverse painting on glass is that it gives a particular unique brightness to the piece of art compared to competing techniques [6]. This is on account of there being no an air gap between the glass and the painting for reverse painting on glass. During the 18th century, Arnaud Vincent de Montpetit invented the Eludoric painting technique, which consisted of painting with an oil binder under a thin layer of water. The painting was then covered with a glass panel pasted with an adhesive [1]. Contrary to this technique, reverse paintings on glass were directly applied to the glass and the technique was considerably developed during the 16th and 18th centuries in Europe and China. The 18th and 19th centuries saw the evolution of this popular technique in Europe [3]. Damage to these specific types of artwork can derive from the glass, the frame, the backboard or from the binding medium and the paint layer [6]. As a result, many museums and art galleries prefer to retain these paintings in storage due to

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preservation and conservation issues. In addition to the development of reverse painting on glass, throughout history, there is currently a significant drive towards the study of such art to improve and enhance current conservation techniques [3,7–9].

The evolution of the glass industry in Europe gave rise to the increased use of transparent properties of glass. For instance, in the 15th century, Venice developed a transparent and flat glass called Cristallo. In France, the Lorraine region became a production centre for glass during the 16th century. Many exchanges between these locations led to the development of the reverse painting on glass technique [1]. Concerning the pictorial layer, many recipes and solutions have been used and, as a result, conservation difficulties are linked to the mixture of many pigments and binders [1,4,9,10]. The lack of standard conformity in the technique of reverse painting on glass provides many challenges today regarding conservation and restoration of these kinds of artworks. What is more, in addition to pigments, silver and gold are also present on reverse paintings on glass, leading to further conservation and restoration implications [6].

Damage to the paint layer can derive from a number of factors, ranging from the way in which the pigments and media are used to storage and handling conditions. These damages generally arise through the detachment of paint layers, loss of colour and fragmentation, and can be strongly linked to the painting technique, the preparation of pigments and the use of media. These factors are necessary to be taken into account when considering preserving the painted artwork [4]. Sometimes, observed glass deterioration (e.g. broken glass, corrosion) can be indicative of decay within the colour layers beneath. Indeed, the study by Neelmeijer [7] shows the necessity to not only understand the deterioration mechanisms of the paint layers but also the interactions between the paint and the glass itself.

The paint layer can also be damaged through photochemical reactions as a result of chemical instability. Furthermore, the penetration of water can create significant deterioration, with the development of microorganisms and the separation between hydrophilic and hydrophobic materials. The failure of adhesion, due to the oxidation of the paint or the effect of light and heat, can lead to powdering, blistering or peeling of the colour layer. What is more, poor restoration techniques can also increase the deterioration [6,10] highlighting the crucial necessity for managing the deterioration of the paint layer for successful conservation.

Storage considerations of reverse paintings on glass are complicated because of the sensitivity of the materials used and also because of the non-standard mixtures implemented by the artist. This is why reverse paintings on glass are less often seen in museums than other paintings. Best practice is to keep these paintings in their frames with the glass side placed face down. The use of acid-free tissue paper is recommended for wrapping the painting before storing in a sealed box, resistant to air and water vapour. This, along with the implementation of an air circulation and filtration system, removes the possibility and likelihood of air pollution. Finally, current recommendations for conserving these artworks are to maintain a stable, optimised environment (T = 18–20 °C; RH = 50–55%) [6,7].

Artworks conservation is heavily linked to the understanding of the materials present. Interactions between the materials and the environment, inter-material reactions and long-term behaviour must be studied to gain a more in-depth understanding of the issues that arise during restoration. The adhesion parameters of a material are heavily linked with the wettability characteristics of that material. As such, considerable amounts of research over a large range of applications have been conducted in the area of adhesion and wettability characteristics [11–16].

This work is focused on material interactions of specific relevance to the oil-based painting technique of reverse painting on glass, and is aimed at making inroads to informing conservation and restoration practice for these rarely studied artworks. The determination of adhesion parameters of pigments on glass is presented and the inter-comparison of different pigments. The effect of adhesive coatings and the relationships between the binder (linseed oil), pigments, glass and adhesive are also investigated.

2. Experimental technique

2.1. Pigments

Nine pigments (L. Cornelissen & Son) were used for this study. Table 1 summarises the pigments and their chemical characteristics [17–20]. The pigments were chosen to implement different particle shapes and sizes in order to observe the influence on the adhesion of the pictorial layer on glass.

2.2. Binder and adhesives

Cold pressed linseed oil was implemented in this study as a binder in the technique of reverse painting on glass. It should be noted here that only one binder was selected to focus on the specific influence of the pigments and adhesives [21].

Adhesives in the technique of cold painting on glass are essential to reinforce the durability of the artwork and as such two were selected for this study: gum arabic and ox gall (Winsor and Newton), both of which were commonly used during the 18th century [22,23]. The gum arabic adhesive was mixed with water (1:1 vol) whereas the ox gall adhesive was used as-received. Both adhesives were applied to the surfaces of glass slide samples and left to dry in air prior to the application of the pigments.

2.3. Support glass

To ensure that the same type of glass was used throughout the experimentation, soda lime glass samples measuring 75 mm^2 and with a thickness of 1.5 mm were used. These samples were cleaned using isopropanol (99.7%; Sigma Aldrich Co.) in an ultrasonic bath for 10 min before any experimentation was carried out.

2.4. Sample preparation for pigment application

Each pigment given in Table 1 was mixed with the binder to obtain a homogeneous paste. In order to compare each pigment, the maximum quantity of oil absorbed by 1 gram of pigment was added to create the pigment paste.

The homogenous pastes were applied to the glass slides in three sets:

- Set 1: The pigment pastes were directly applied to the soda lime glass samples.
- Set 2: The pigment pastes were applied to the soda lime glass samples which had previously been prepared with the mixture of gum arabic and water adhesive.
- Set 3: The pigment pastes were applied to the soda lime glass samples which had previously been prepared with the ox gall adhesive.

Four slides prepared with each adhesive were also used as a control and for the wettability characteristics and topography analyses.

2.5. Accelerated ageing

Accelerated ageing treatments were conducted on those samples which included the presence of the adhesives, in accordance with the procedures detailed by Feller [24]. The treatments were