Characterisation of Glass and Painting Materials from 18th-Century Hand-Painted Glass Slides Used for Projection with Magic Lanterns

AUTHORS

Ângela Santos*
PhD Fellow, Department of Conservation and Restoration & Research Unit VICARTE, NOVA School of Science and Technology (FCT NOVA), Caparica, Portugal
aba.santos@campus.fct.unl.pt

Vanessa Otero
Researcher, Department of Conservation and Restoration & Research Unit LAQV–REQUIMTE, NOVA School of Science and Technology (FCT NOVA), Caparica, Portugal
van_otero@campus.fct.unl.pt

Márcia Vilarigues
Assistant Professor, Department of Conservation and Restoration & Research Unit VICARTE, NOVA School of Science and Technology (FCT NOVA), Caparica, Portugal
mgv@fct.unl.pt

**Corresponding Author*

KEYWORDS

Magic lantern slides · Glass painting · Cold paint · Characterisation

INTRODUCTION

The magic lantern was invented in the middle of the 17th century, marking the beginning of what is called the "pre-cinema period," and became the first popular apparatus for the projection of images. This instrument was widely used for children and adult entertainment, dissemination of educational topics, religion, and advertisement during the 18th and 19th centuries. (Schlosser 1980, 10)

The first images projected by magic lanterns were hand painted on thin glass slides with watercolours, oils, and varnish colours. This technique required the expertise and skill of painting detailed miniatures on a glass surface with enough perfection to be magnified.

Besides the inherent difficulty of painting on a glass surface, the artists needed the most transparent and vivid colours to face the challenge of playing with light and shadow effects (Frutos 2013, 3; Hughes 1893, 145). Due to the complexity of these paintings and their exposure to aggressive conditions of temperature, light, and handling during the projections, they represent a significant challenge for conservation professionals.

During the 19th century, hand painting was gradually complemented with printing techniques for the outlines and later replaced by photographic techniques occasionally coloured by hand. (Frutos 2013, 3)

To identify the techniques and materials used in the early stages of production of these artefacts, eleven 18th-century Italian magic lantern hand-painted glass slides from the collection of Cinemateca Portuguesa – Museu do Cinema were studied (Figure 1).

The historical written sources can provide essential information in understanding how these objects were conceived in terms of production techniques and materials used, and their evolution over time (Carlyle 1995). During the 18th and 19th centuries, several books with instructions of how to paint transparencies on glass for magic lanterns were published. These texts give us insight into which materials we can expect on historical magic lantern slides.

Earlier documents refer to the importance of selecting good quality glass for the substrate

Figure 1. *Hand-painted magic lantern glass slides. Italy, 18th century CE. Cinemateca Portuguesa - Museu do Cinema, FCT.V.CP.01-11 · Courtesy of Cinemateca Portuguesa - Museu do Cinema*

(e.g. crystal glass from France or Bohemia, or flattened crown glass for common subjects and plate glass for a refined execution). Among the materials used, the authors frequently advise the use of watercolours, sometimes combined with oil paints, and varnishes mixed with the colours to give them more transparency or applied on top for protection. (Frutos 2013, 4–5; Groom 1855, 12–13)

Microcracking, paint detachment, and colour alteration induced by the conditions of projection are frequently found on historical slides. These conservation problems may be associated with the production technique.

METHODS

To assess the preservation state of the pictorial layers, the painting surfaces were examined under a stereomicroscope, and micro-sampling was performed on flaking areas.

The glass was characterised using Energy Dispersive X-Ray Fluorescence Spectrometry (μ-EDXRF), and the identification of the painting materials was performed by Fourier Transform Infrared Spectroscopy (μ-FTIR) and Raman Spectroscopy (μ-Raman).

__Figure 2.__ Detail of the hand-painted magic lantern glass slide CP.10, as an example of severe microcracking and paint detachment that can be observed in this slide's set

RESULTS AND DISCUSSION

When examining these artefacts, some damages became evident: CP.01 was the most heavily damaged slide with almost all the painting layer lost, CP.07 was missing its wooden frame, and CP.09 and CP.11 sustained fractures and glass loss. Overall, the glass on all slides appears to be in stable condition with no signs of deterioration observed. Although some of the slides still preserve a significant part of the painting, under the stereomicroscope, it is possible to identify severe microcracking covering all the slides' pictorial layers. The absence of the paint's adhesion to the glass surface was also diagnosed (Figure 2).

Preliminary results by μ-EDXRF analysis of the glass substrate revealed that all the glass slides have the same composition and can be classified as soda-lime glass. The exact composition is currently under investigation. By comparing the spectra of the glass with those of the paints, it was possible to detect some of the elements associated with the paint colourants. Iron (Fe) was identified as the main colourant of the dark and light blue paints. The green paint has copper as the colourant (Figure 3a), and the blue-green paint spectra indicate that it was obtained by mixing iron blue with copper green. The absence of identified colourant elements on the yellow, red, and black paints suggest their organic nature, and the

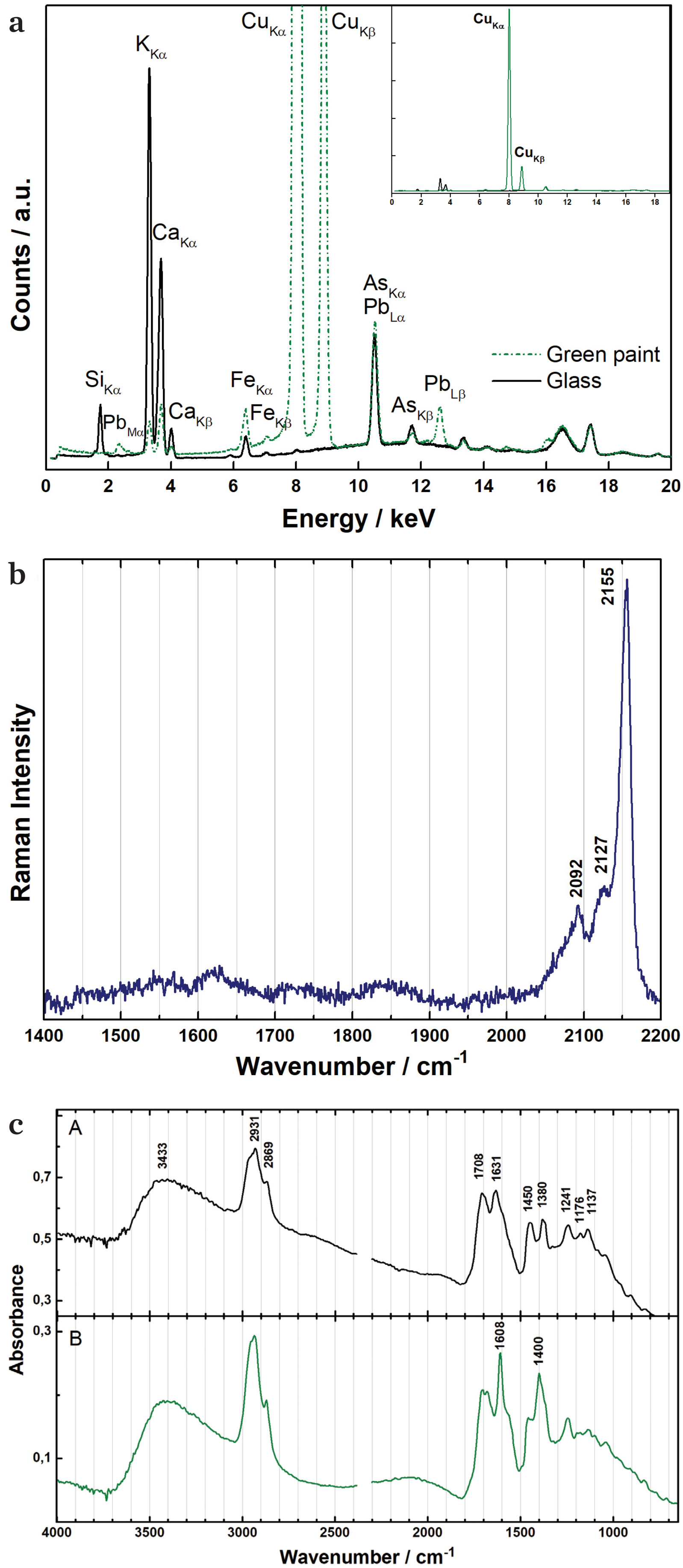

Figure 3. Preliminary results:
a) µ-EDXRF spectra of green paint in comparison with the glass substrate;
b) µ-Raman spectra of the dark blue paint identified as Prussian blue (using a 632.8-nm laser);
c) µ-FTIR spectra: yellow varnish/binder (A) and green paint (B).

presence of copper in the brown paint can indicate a mixture of an organic colourant with the copper green.

With μ-Raman, it was possible to identify the black paint as a carbon black and the dark blue pigment as Prussian blue ($Fe_4[Fe(CN)_6]_3$) due to the υ(CN) characteristic bands (Figure 3b) (Barsan et al. 2011).

Analysis with μ-FTIR suggests the use of the same binder in all colours. Preliminary results indicate the existence of a triterpenoid resin, such as mastic (Figure 3c). The widening of its characteristic bands at 3100-2800 cm^{-1} (υ(C-H)) and 1708 cm^{-1} (υ(C=O)) bands to higher wavenumbers and the peak at 1380 cm^{-1} (δ(C-H) can indicate a mixture, possibly with shellac resin (Derrick, Stulik, and Landry 1999). The copper green paint exhibits characteristic bands of a copper carboxylate at 1608 and 1400 cm^{-1} due to υ(COO-). The natural formation of copper carboxylates, when copper(II) is in contact with resinic and fatty acids, has been studied (Gunn et al. 2002; Otero et al. 2014). When sampling this paint, a colour difference between the layer in contact with the glass (bottom) and the top layer was detected; the bottom revealed a vivid green colour, and the top a darker yellowish tone. This difference opens a discussion about its nature, whether the carboxylates were initially present in the paint (e.g. if it was used a copper pigment with a varnish applied on top), or if the carboxylates are a degradation product. The green paint will be stratigraphically studied to answer this question.

Regarding the red and yellow colourants, it was not possible to identify them so far with μ-Raman and μ-FTIR. Since the infrared spectra of the yellow and binder/varnish are similar, the use of resin as yellow colourant should not be excluded; however, further analysis will be performed to assess its composition. To fully characterise these colourants, the use of Microspectrofluorimetry will also be explored.

CONCLUSIONS AND FUTURE WORK

Due to the complexity of this set of hand-painted magic lantern slides, a multi-analytical approach proved to be essential for the characterisation of the materials and assessment of the conservation state.

The glass appears to be in stable condition with no signs of deterioration observed, and the preliminary study indicates that it is soda-lime glass. The exact composition is currently under investigation to increase knowledge on its production.

Analysis of the painting materials determined that all paints have the same resinous binder or varnish applied. Nevertheless, to better understand how these paints were created, samples will be examined in cross-section.

X-ray fluorescence, infrared, and Raman analysis allowed the identification of Prussian blue on dark, light, and green-blue areas. The black paint was identified as carbon black, and the green presents copper carboxylates, also visible in the blue-green and brown colours. Further investigation by μ-FTIR, Optical Microscopy (OM), Fibre-Optic Reflectance Spectroscopy (FORS), and Microspectrofluorimetry will be conducted for the identification of all colourants.

Given the current state of preservation and danger of total loss of the paint, preventive conservation solutions need to be studied and implemented to stabilize these artefacts. The knowledge acquired by the powerful combination of investigating the material aspects of magic lantern glass slides will directly impact their preservation, interpretation, and appreciation.

ACKNOWLEDGEMENTS

The authors acknowledge the Portuguese Foundation for Science and Technology (FCT-MCTES) for PhD grant PD/BD/136694/2018, the Research Units VICARTE (UID/EAT/00729/2019) and LAQV-REQUIMTE (UID/QUI/50006/2019) for supporting this project. The authors are also grateful to Prof. Dr Maria João Melo for her support on FTIR analysis and Cinemateca Portuguesa – Museu do Cinema for the collaboration with this project (*Lanterna Magica* – Technology and Preservation of Painted Glass Slides for Projection with Magic Lanterns).

REFERENCES

Barsan, M.M., I.S. Butler, J. Fitzpatrick, and D.F.R. Gilson. 2011. High-pressure studies of the micro-Raman spectra of iron cyanide complexes: Prussian blue (Fe4[Fe(CN)6]3), potassium ferricyanide (K3[Fe(CN)6]), and sodium nitroprusside (Na2[Fe(CN)5(NO)]·2H2O). *Journal of Raman Spectroscopy* 42(9): 1820–1824.

Carlyle, L. 1995. Beyond a collection of data: What we can learn from documentary sources on artists' materials and techniques. In *Preprints: historical painting techniques, materials, and studio practice, Leiden, 26-29 June 1995*, eds. E. Hermens and M. Peek, 1-5. Los Angeles: The J. Paul Getty Trust.

Derrick, M.R., D. Stulik, and J.M. Landry. 1999. *Infrared spectroscopy in conservation science (Scientific Tools for Conservation)*. Los Angeles: The Getty Conservation Institute.

Frutos, F.J. 2013. From luminous pictures to transparent photographs: The evolution of techniques for making magic lantern slides. *The Magic Lantern Gazette* 25(3): 3–11.

Groom, E. 1855. *The art of transparent painting on glass*. London: Winsor and Newton, Limited.

Gunn, M., G. Chottard, E. Rivière, J.J. Girerd, and J.C. Chottard. 2002. Chemical reactions between copper pigments and oleoresinous media. *Studies in Conservation* 47(1): 12–23.

Hughes, W.C. 1893. *The art of projection and complete magic lantern manual*. London: E.A. Beckett.

Otero, V., D. Sanches, C. Montagner, M. Vilarigues, L. Carlyle, J.A. Lopes, and M.J. Melo. 2014. Characterisation of metal carboxylates by Raman and infrared spectroscopy in works of art. *Journal of Raman Spectroscopy* 45(11-12): 1197–1206.

Schlosser, H.. 1980. Magic lantern slides - A legitimate art form. *Spinning Wheel: Antiques & Early Crafts* 36(1): 8–11.

Silva, C.E., L.P. Silva, H.G.M. Edwards, and L.F.C. de Oliveira. 2006. Diffuse reflection FTIR spectral database of dyes and pigments. *Analytical and Bioanalytical Chemistry* 386(7-8): 2183–2191.