10 Years of Free Web Access
e-PRESERVATIONScience

e-PS, 2013, **10**, 42-49
ISSN: 1581-9280 web edition
ISSN: 1854-3928 print edition

e-Preservation Science (e-PS)

is published by Morana RTD d.o.o.
www.Morana-rtd.com

SCIENTIFIC PAPER

This paper is based on a presentation at the 31st international meeting of Dyes in History and Archaeology (DHA) in Antwerp, Belgium, 18-20 October 2012.

Guest editor:
André Verhecken.

CARING FOR QUEEN VICTORIA'S PRIVY COUNCIL DRESS C. 1837: AN INVESTIGATION OF THE UNIQUE DISCOLOURATION OF THE BLACK SILK

Mika Takami*[1], Ina Vanden Berghe[2]

1. Historic Royal Palaces, Apt 59 CCC, Hampton Court Palace, Surrey KT8 9AU, UK

2. Royal Institute for Cultural Heritage, Jubelpark 1, BE-1000 Brussels, Belgium

corresponding author:
mika.takami@hrp.org.uk

Abstract

Queen Victoria's famous silk dress, worn on the first day of her reign, was originally black but now appears as a blotchy brown colour. This discolouration has happened throughout the whole dress, inside, outside and even within the seams. This discolouration, combined with the otherwise apparently well preserved state of the fabric is unique, requiring in-depth study to support the conservation treatment decisions and the strategy for the dress's long-term future preservation.

Dyes and mordants were investigated using HPLC-DAD and SEM-EDX. The dye analysis confirmed the use of logwood and tannin together with iron and copper mordants. Fading could be attributed to the loss of haematoxylin, though why intense discolouration occurred uniformly still remains a conundrum. Back-scattered electron images further revealed severe silk degradation. However, the main silk fabric still feels sound and flexible to the touch showing little sign of brittleness, unlike common findings in the late 19th century weighted, black-dyed silk.

This paper identifies the unknown elements still to be answered to establish the full picture of the on-going fading and fibre degradation. It also describes the conservation perspective and areas for further study to predict or influence the eventual fate of the dress.

received: 30/12/2012
accepted: 26/03/2013

key words:
Black silk, logwood, discolouration, silk degradation, iron and copper mordants, conservation

1 Introduction

This paper concerns the severe discolouration of a 19th century black silk dress. The dress required a minimal amount of stitched conservation treatment before it went on display in a new exhibition '*Victoria Revealed*' at Kensington Palace in March 2012 (Fig. 1). Research was undertaken to better understand the cause of this discolouration, in order to establish optimum display conditions for its long-term preservation, in particular to prevent further colour loss and degradation of the silk.

Fading and degradation are not unfamiliar problems for silk which has been weighted and dyed black in past centuries. This dress is no exception. The dress now appears as a brown colour showing no evidence of the original black colour. However, what makes this dress unique is its distinctive mottled discolouration pattern and the fact that this blotched brown

Figure 1: Overall view of the dress, March 2012 (Royal Collection Trust/© Her Majesty Queen Elizabeth II 2012).

Figure 2: Discolouration of the dress: (a) overall view with (b) details of mottled appearance.

is uniform to the same extent throughout the entire dress, both inside and out, even in the most hidden areas such as under the hems and inside the pleats and the seam allowances on the inside of the dress (Fig. 2). Furthermore, the silk fabric of this dress remains sound and stable, unusually being neither brittle nor shattering. Severe degradation of the fibres is normally expected with black silk of this period that has faded to this extent, but the dress was strong enough to withstand the amount of handling required for mounting on a mannequin for display in 2012, without causing any damage.

2 The dress

2.1 Background

This slender, barely adorned silk dress was worn by young Princess Victoria, then just 18 years old, on the very first day of her reign, when she held her first meeting of the Privy Council at Kensington Palace on 20

Figure 3: *Queen Victoria Presiding at her First Council* (1838) by Sir David Wilike (Royal Collection Trust/© Her Majesty Queen Elizabeth II 2012).

June 1837, only five hours after being woken with the news of the death of her elderly uncle, William IV. The dress was black for mourning. Unfortunately there is no existing image or illustration which features this dress in black. Queen Victoria was portrayed in a white satin dress in the painting created a year later depicting this first meeting of her council (Fig. 3). This change of colour was the artist's deliberate intention in order to capture her youthfulness as well as the calm demeanour manner with which she impressed her Ministers, but Queen Victoria's own note written later confirms that she was in black at the First Privy Council. [1]

2.2 Materials and construction

The dress is entirely made of silk except the white lace-trimmed, embroidered cotton cuffs and has the style of a wide scoop neck with long puffed sleeves and a straight waistband in a slightly high position, reflecting the older style. The fashion plates suggest that this style was common in July 1837.[2,3] The bodice part is made of the faded brown silk lined with plain weave white silk and fastened with hooks and eyes at the centre back (Fig. 4). The neckline is bound with a purple piping to encase a drawstring of purple silk ribbon (Fig. 5). The same purple piping is used to finish the cuffs.

Figure 4: White silk lining.

Figure 5: Purple silk draw strings.

Figure 6: Purple silk skirt lining.

Figure 7: Double vertical frill decoration.

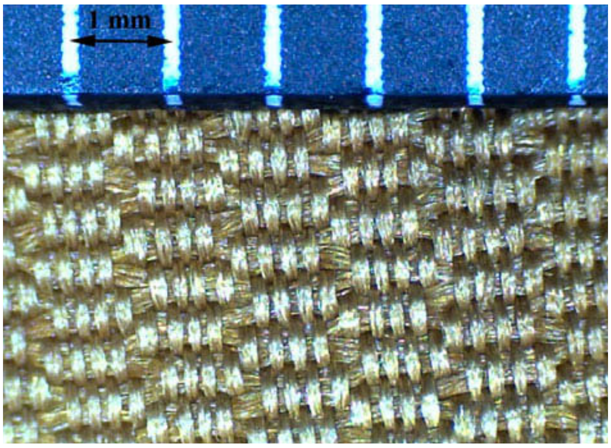

Figure 8: The weave of the main silk.

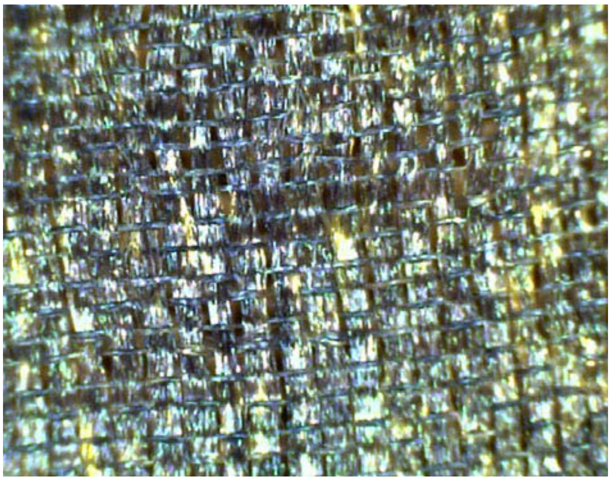

Figure 9: The weave of the skirt lining.

The skirt, made of the faded brown silk, is pleated towards the centre front and gathered either side of the centre back. A short strip of purple silk lining in a fine plain weave is attached above the hem (Fig. 6). The front of the skirt is decorated with a double vertical frill (Fig. 7), with the vertical line accentuated with the purple piping. Close examination confirms that there is no evidence of any later alterations.

Both warp and weft in the main dress fabric are silk. The fabric is firm and close-woven in a type of grosgrain with ribs in a unique brick pattern formed in alternating multiple weft threads (Fig. 8). The fabric would be thicker than a taffeta or twill. The purple skirt hem lining is in a plain weave, with a much finer weft (Fig. 9).

It is not certain when the discolouration of the dress started to occur. It is evident that the main silk faded to mottled brown whereas the other black silk components faded to purple. The historic records indicate that the dress was once catalogued as 'blue' and that it was possibly dipped for quick economical black dyeing.[4] However the latter account can be readily discounted as the fine white silk lining, which is without doubt in its original form from its construction, still remains intact and pristine on the inside of the bodice.

Despite the significant discolouration, the dress was in a relatively sound condition when examined in 2011. The main silk felt slightly brittle to touch but overall it remained flexible in handling. The dress exhibited minor structural weakness such as partially broken seams. This damage was due to the black dyed stitching threads being brittle and easy to break.

2.3 Past displays and storage

The dress was preserved by the Queen herself throughout her reign until 1901. After her death the dress has most likely been kept by Queen Alexandra and Queen Mary who inherited a quantity of the early clothes of Queen Victoria. The next earliest record available suggests that the dress was given to the London Museum as a loan by Queen Mary in 1920[I] where it remained until 1998.

The London Museum exhibited the selection of loaned royal costumes when the museum was first opened in Kensington Palace in 1912. The London Museum then moved to Stafford House (later renamed Lancaster House) at St James in 1913 and re-opened to the public in 1914. Whether the dress was displayed during this period is unknown. The London Museum collection was moved from Lancaster House for safety during the two World Wars and remained in storage until 1950. Whilst the collection move during the WWI was inconsequential to this dress as it happened before 1920, no record of locations at which the dress was stored during the WWII removals has been found. The museum re-opened at Kensington Palace in 1951 and remained open to the public until 1975 when it moved to the new venue, London Wall.[II] The dress might have been shown in the State Apartments in Kensington Palace which were part of the museum from 1955 to 1972 but there is no direct evidence. Even if the dress had been displayed, it would only have been very occasionally. The London Museum was aware of the potential damage to textiles from prolonged display and had limited the number of costumes exhibited at any one time since an early date.[5]

2.4 Conservation treatments

The clear evidence of display only starts from 1987. On the 150^{th} anniversary of Queen Victoria's accession to the throne, the dress was displayed for three months in the new Museum of London. It was then displayed again for a six-month exhibition '*In Royal Fashion*' which opened in May 1997 following a conservation treatment. The condition and treatment record then describes the structural weakness in the seams and fastenings but overall the dress fabric was sound although extensively discoloured. The white cuffs were removed and wet-cleaned, whereas the dress was reinforced with stitching the weakening areas. After the exhibition in 1998, the dress was transferred from Museum of London to Kensington Palace to become a part of the Royal Ceremonial Dress Collections of Historic Royal Palaces. In 2001 the dress was again displayed for a one-year exhibition. Prior to display, the white cuffs were wet-cleaned again, but the dress received a minimal stitched treatment only to reinforce the weak areas. In 2011, again the broken seams and hem were repaired with a minimal amount of stitching and no treatment was carried out on the cotton cuffs.

The blotchy mottled pattern on the brown silk fabric was carefully compared with the same locations in the photographs from 2001 but the visual assessment was limited and no obvious change was detected. The colour measurements were taken for future reference but it was also decided to carry out an in-depth dye analysis in order to understand the on-going fading/ discolouration mechanisms of the silk and evaluate the true state of fibre degradation in the silk fibre for appropriate conservation strategy.

3 Experimental

Information about the silk weighting and dyeing treatment is indispensable to understand the on-going fading/ discolouration mechanisms of the silk. The well-preserved condition of the dress hampered sampling from the outer side of the main silk. Nevertheless, four samples were taken from threads with different function in the dress. Organic dye and weighting compounds were investigated using high performance liquid chromatography, while scanning electron microscopy with X-ray energy detection (SEM-EDX) was applied for the identification of inorganic elements.

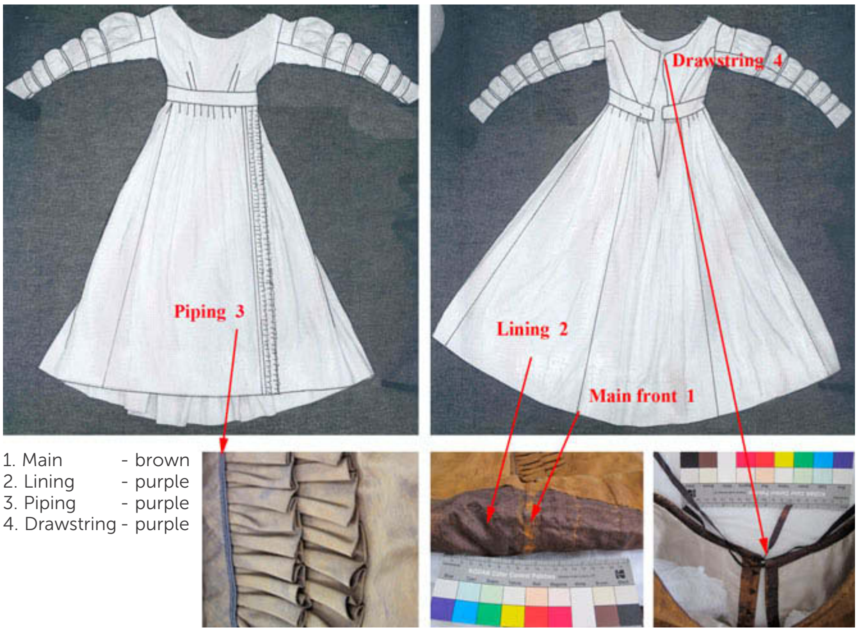

Figure 10: Samples taken from the dress (1), the lining (2), the satin piping (3) and the draw string (4).

3.1 Samples

During the recent conservation four small silk samples could be taken (Fig. 10). One from the main dress, taken at the inner side, these threads are actually pale brownish. A second sample was taken from the silk lining of the dress which is actually dark purple, while the third and last samples were respectively obtained from the actually dark purple satin piping band on the front side of the dress and the dark purple drawstring at the neck.

3.2 Techniques

3.2.1 HPLC-DAD

The organic dyes are recovered from the fibres by extraction with 250 µl water/ methanol pure / 37% hydrochloric acid in the volumetric ratio of (1/1/2, v/v/v) for 10 min at 105 °C. After filtering, the clear filtrate is dried by vacuum evaporation and the dried residue redissolved in 60 µl methanol/water (1/1, v/v) from which 20 µl will be analysed. The analyses are executed on an Alliance HPLC system with autosampler, a diode array detection system (PDA model 996) and data treatment software Empower 2, all from Waters. A RP-18 column is used (Lichrosorb (VWR), 125 mm x 4 mm diameter, 100 Å pore diameter and 5 µm particle size) at fixed temperature of 25 °C, while the mobile phase consists of a linear gradient of methanol, water and phosphoric acid at a constant flow rate of 1.2 ml/min during 35 min. The dye compounds are characterised by their elution time and their UV-visible absorbance spectra, which is compared against a non-commercial internal developed database.

3.2.2 SEM-EDX

Inorganic mordants or weighting products are investigated through element analysis using scanning electron microscopy with energy dispersive X-ray detection (Jeol, Oxford Instruments) using 15 keV incident electron voltage. The samples are positioned on a round supporting tablet and covered with a carbon layer prior to analysis.

4 Results and Discussion

4.1 Black dyeing and weighting of the silk dress

4.1.1 Organic dyes

Ellagic acid was found in the dress, the lining and the satin piping but was not detected in the ribbon at the neckopening. The presence of this compound in the silk fibres might refer to the use of tannin as part of the dyeing process, but one cannot exclude it being used rather as weighting agent for silk. A second compound, a derivative of hematoxylin obtained by the acidic hydrolysis step to recover the dyes from the silk fibres, was found in all silk samples.[6] This compound (Fig. 11) suggests the use of the heartwood of logwood tree (*Haematoxylum campechianum* L.), native to Central America as well as the West Indies.[7] Apart from these major compounds, also traces of flavonoid compounds such as quercetin and kampferol but also luteolin and apigenin were found in the main dress as well as in the lining, indicating the use of sumac and/or alderbark for black dyeing in combination with a yellow dye source like weld (*Reseda luteola* L.), sawwort (*Serratula tinctoria* L.) or dyer's broom (*Genista tinctoria* L.).[8] Semi-quantitative evaluation of the first three samples based on the ratio between ellagic acid with absorbance peak observed at 254 nm, and the hematoxylin marker with absorbance peak detected at 450 nm (Fig. 11) suggest that the amount of ellagic acid relative to hematoxylin derivative is higher in the silk from the main dress fabric than in the lining and the satin piping. In general we can conclude that the composition of the main organic compounds is very similar in the first three samples. The silk from the ribbon at the neck is the only one not weighted with tannin and only dyed with logwood.

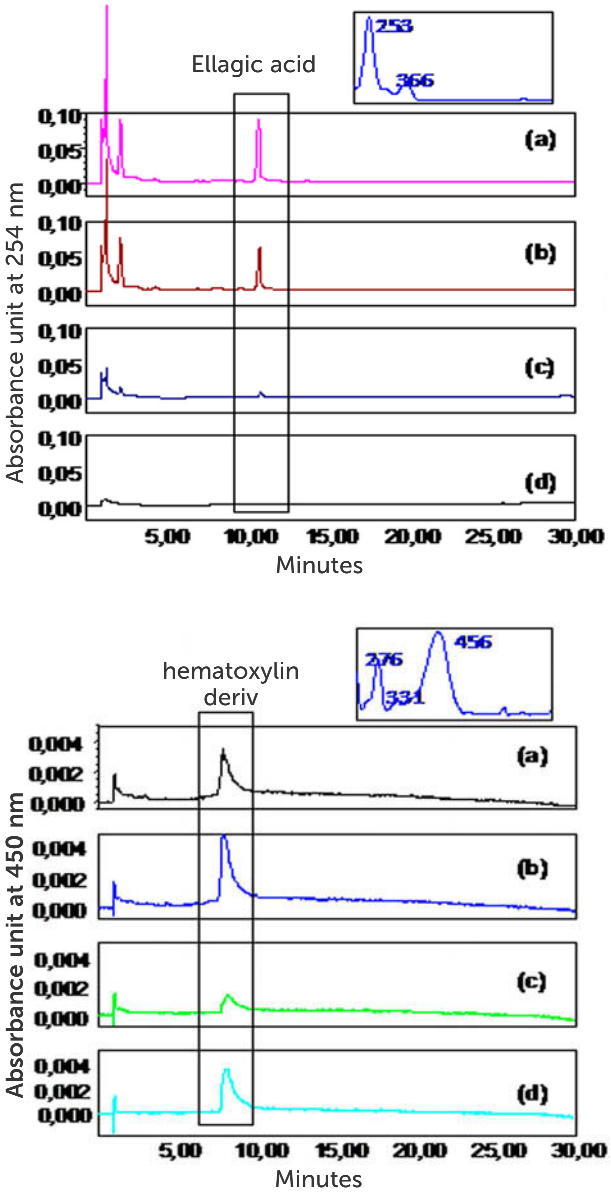

Figure 11: HPLC-DAD chromatograms of the four samples, (a) main silk, (b) lining, (c) satin piping and (d) neck ribbon, taken at 254 and 450 nm with the peaks of hematoxylin derivative and ellagic acid.

4.1.2 Inorganic elements

Element analysis of the silk of main dress revealed the presence of high amounts of calcium and sodium on the fibre surface but also locally high peaks of chloride and iron were found together with minor peaks of chromium and copper (Tab. 1) This silk was black dyed with the help of iron salts containing copper. The silk lining sample contains significant amounts of potassium, sodium, aluminium, sulphur and magnesium, possibly suggesting the use of alum as mordant. However, iron and copper were detected though much less pronounced than in the main silk threads. The silk filaments from the satin piping on the front of the dress seem to be covered by a surface layer (Fig. 12). Iron, copper, potassium and sulphur are the main elements detected locally in very high amounts, on as well as beneath the top layer. Element analysis of the silk filaments from the ribbon suggests the use of alum, similar as in the silk from the main dress. Small amounts of iron and copper were found only locally. The detection of silver is only found at one spot so most probably should be interpreted as a contamination (of an ornament such as a necklace?).

		Detected elements											
Silk threads:	Specification analysis area:	Na	Mg	Al	Si	S	Cl	K	Ca	Cr	Fe	Cu	Ag
1. silk from main dress	all over surface	++	(+)	+	(+)	+		(+)	++			(+)	
	local spots			(+)	(+)	(+)	++	(+)	(+)	+	++	+	
2. silk lining	all over surface	++	+	++	+	++		++			(+)	(+)	
	local spots	++	+	++	+	++		++			(+)	(+)	
3. satin piping	surface layer					++		++			++	++	
	beneath surface layer					++		++			++	++	
	local spots					+		+			++	++	
4. silk ribbon (neck opening)	all over surface	++	+	++	+	++		++	+		(+)	(+)	
	local spots	++	+	++	+	++		++	+		(+)	(+)	++

Table 1: Semi-quantitative element analyses (EDX) of the four silk samples from the dress (most elements: ++; medium elements: +; less prominent elements: (+)).

4.1.3 Historical context of the black dyed and weighted silk dress

The organic dye and tannin identification together with the detection of the inorganic elements applied gives concrete information about the way the silks were weighted and black dyed. Weighting of the silk was done for economic reasons (more weight) but also to obtain an improved appearance of the silk (more volume, more lustre). In case the silk had to be dyed in black, weighting and dyeing were done combining tannin and other organic dye sources together with metal salts, often using multiple cycles to obtain high yields of weighting and dark black saturated shades.[9] Till the end of the 18th century, the most common way for weighting and black dyeing of silk was by the combination of tannin from gallnuts, sumac (*Rhus* genus) or alderbark (*Alnus glutinosa* L.) and copperas, green vitriol (ferrous sulphate) and/or iron filings often even in the presence of alum.[10] In the 19th century, logwood became an established organic dye source systematically added to the silk black dyeing process.[11]

The analyses show that the main silk was weighted and black dyed with a high amount of tannin, derived from sources as sumac, galls and alder bark, together with logwood and metal salts, mainly iron salts (chlorides) but also copper and chromium salts. The lining was dyed with logwood and tannin together with alum and small amounts of iron and copper salts, which could result from contamination from the main dress. The silk piping thread was also dyed with logwood and tannin, though these silk threads clearly contain more metal salts, iron sulphates as well as copper sulphates. The relative ratio of copper/iron is much higher than in the other samples. Possibly Spanish green (copper acetate) was applied here together with green vitriol (ferrous sulphate). The silk ribbon thread was dyed with logwood and alum. No tannin was found and little evidence of iron and copper salts.

The way the silks from the dress were weighted and dyed is completely in accordance with the customs of black dyeing of silk in the first half of the 19th century before tin weighting came into use.

4.2 Degradation aspects

4.2.1 Colour fading

The main issue of the study is the very pronounced fading of the black silk which markedly changed into a yellow/brown shade with a very mottled appearance all over the dress (Fig. 2), even under the seams. This suggests that light exposure alone is not the basis of the ongoing fading mechanism. The areas where the colour has better survived are the parts under the arms, indicating that sweat must have had a stabilising effect on the colour degradation. This implies that the discolouration is highly pH sensitivity. The current overall yellow/brown shade of the dress is most likely the result of the loss of haematoxylin. This is confirmed by the lower overall amount of metal elements left on these silk filaments (Tab. 1). Conversely, the actual dark purple faded lining, satin piping and silk ribbon still contain significantly higher amounts of metal salts, which secure the bond between the dye compound and the silk fibres.

4.2.2 Fibre degradation

Despite the severe fading problem, the silk threads still have a soft handle. Due to the lack of brittleness, the dress was still considered to be in a good state of preservation, allowing it to be exhibited. Dye and element analyses however enhanced the fear about the actual condition of the silk fibres which was confirmed with the study of the surface morphology of the fibres. Despite the apparent good state of the fibres visually, severe fibre degradation is ongoing and will probably cause a complete loss of the silk in the near future. The silks from the main dress, the lining and the ribbon at the neck show a similar degradation pattern having filaments that seem to cluster together, with heavily damaged surfaces consisting of crater-like holes all over the length (Fig. 12). The back- scattered image of the silk from the satin piping shows a completely different deterioration aspect. The threads seem to be covered by a layer at the surface which is actually breaking and peeling off (Fig. 13) but no holes are observed. The different degradation pattern of this silk compared to the others is possibly related to the higher content of iron(II) and copper(II)sulphates in this sample but this does not explain the existence of the outer layer. Heavy weighting could be a possible cause of the formation of this surrounding mantle but also the existence of a sizing top layer is another possibility.[III] However, the presence of iron and copper ele-

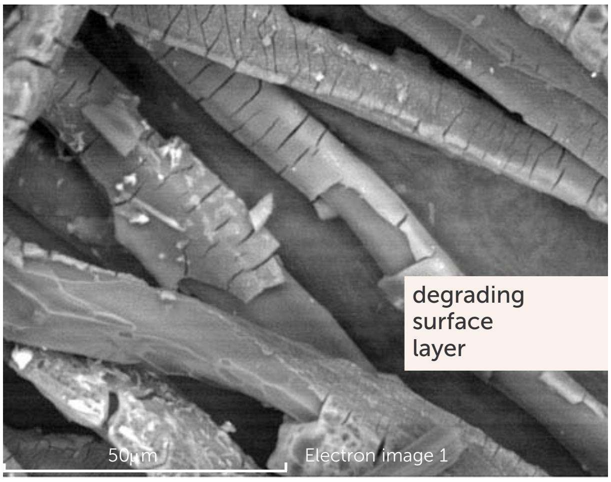

Figure 13: Morphology of degradation of the filaments from the satin piping decoration at the front side of the dress (back-scattered electron image).

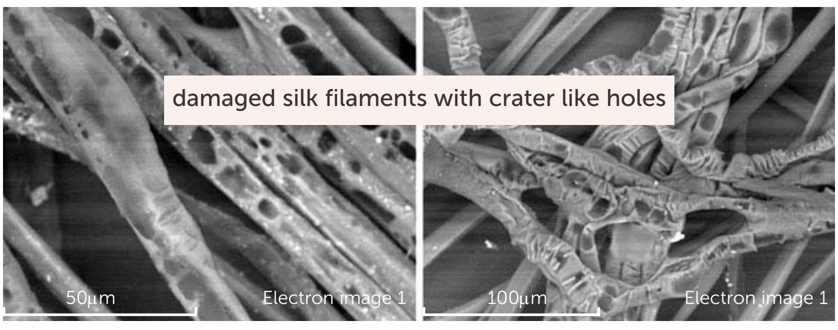

Figure 12: Morphology of degradation of the filaments from the main silk, the lining and the black ribbon at the neck (back-scattered electron images).

ments both on top as well as under the outer layer argues against the latter option.

As little information exists about the dress's history, and no other samples could be taken from the dress for further investigation of the fibre degradation, the most important parameters assumed to play a role in this case are discussed further. Different aspects of silk degradation have been investigated intensively the last years using near infrared spectroscopy, X-ray diffraction, polarised ATR spectroscopy, size exclusion and high performance liquid chromatography as well as tensile strength tests though none of them dealt with silk weighting as such.[12-19] An increased acidity of silk was found to be inherent to silk ageing irrespective of the ageing regime by light, heat or heat with high humidity, in air.[20]

On-going oxidative degradation of silk black dyed with iron and galls could be characterised by the high amount of cysteic acid formed out of cystein and cystin, initiated already by the black dyeing process and further pronounced after ageing. Beyond that, a high correlation between increasing acidity and tensile strength loss, evidenced by another study on iron-weighted silk, defines the major role of acidity in silk deterioration.[16,21]

The weighting and black dyeing technology applied in Queen Victoria's dress is very similar to the extensively studied iron gall-ink problem on paper and parchment manuscripts. From this field, it is known that free Fe^{2+} ions catalyse oxidation reactions in cellulose as well as in collagen, which result in discolouration as well as mechanical decay of the polymers at a later stage.[22] The excess of Fe(II)sulphate is the major cause of deterioration, more important than acidity as such. This negative influence is even more pronounced when copper and iron ions are found together. Another important aspect resulting from iron gall ink corrosion studies is the major catalytic effect of environmental parameters, especially the presence of water or high humidity (> 70 % RH) on iron salt degradation as such conditions enhance migration of free iron ions.[23]

Although fibre degradation is not detected yet visually, on-going silk deterioration is evidenced by the electron images. Multiple parameters such as the excess of ferrous sulphate on the fibres, the presence of copper ions, the acidity of the silk together with conditions of high humidity or water can be considered as major factors in the on-going deterioration to influence the preservation of the dress.

5 Supporting evidence and further queries

It is noteworthy that the white lining for the bodice still remains virtually pristine with no evidence of alteration or yellowing or other staining transferred from the faded main silk. This unaltered condition suggests that the dress was never washed in water in the past. From the archival records, at no stage of the modern conservation treatments has the dress ever been wet-cleaned; only the white cuffs have been wet-cleaned after being separated from the dress. The dress has only been surface cleaned to remove dust. This suggests that the inherent acids and/or the acidic degradation products have never been reduced and remain in the dress.

The lack of evidence of later alteration suggests that this black mourning dress may never have been worn since 1837. The official mourning period of William IV's death was ended by the celebration of Victoria's coronation a year later, followed by her wedding to Prince Albert in 1840 and the arrival of her first child later the same year. In addition, women's fashions changed rapidly in the early Victorian period. If the dress had been altered to bring it up to date with changes in fashion, there would have been evidence of these changes in the dress.

Regarding the past storage conditions, the dress was probably kept in a wardrobe by the Royal Family until 1920. The level of acidity and humidity in the store during this time will remain unknown. From 1920 onwards, except during the war periods, it is reasonable to assume the dress was kept in standard museum-storage conditions as it was in the care of the London Museum. There is no evidence of either sharp creasing or fading directly associated with inappropriate storage. There is no insect damage or staining by mould or mildew, or any kind of water marks evident in the dress.

Whether or not the dress was ever treated with a dry substance, solvents or gaseous materials for cleaning or pests during the early- or mid-20th Century remains unknown. It is possible that a 'dry' cleaning method might have been carried out in a 'home remedy' way. If it had been treated with arsenic for pests, this would have been detected in the elemental analysis. If fumigation by gas was ever carried out, it would have been more likely to be for a number of items in the collection, and therefore a record of expenditure might reasonably be expected to have been found in the museum records.

The dyes and weighting agents applied to the silk could have created a very acidic environment overall, but so far the silk fabric has survived well and still remains sound. Exposure to light in the past must have contributed to the oxidation of the dyes and silk, but the overall discolouration of the dress cannot be attributed to light alone, as the hidden areas have also lost colour. The apparent impact from light is only evident in fading along the top of the skirt pleats, where the silk is paler and a lighter brown than the rest of the dress.

The evidence above supports the interpretation of the analytical results, but it also leads to further queries: when and how this discolouration started to occur; how rapidly and slowly the discolouration is still in progress; whether the dress is still off-gassing; and if it would have a strong oxidative degrading effect on itself if it remains in a sealed environment. The eventual fate of the dress might be that the mottled discolouration will turn into a golden brown or the silk fibre could start disintegrating. In order to prevent or slow down the degradation process, as many relevant parameters as possible, such as light, relative humidity and oxygen and/or acidity level in the environment, need to be identified and addressed.

6 Areas for further research

The discolouration is most probably caused by the loss of haematoxylin, though more research should be done to better understand the parameters of the degradation mechanism behind it. Further analytical investigation is also essential in the following areas: to test the off-gassing from the dress in the current sealed showcase; to measure and monitor colour change over time; and to test for possible finishing agents using FT-IR. More archival research is also needed to fill the gaps in the known history of the display and storage of the dress. Comparative studies of the materials and deterioration mechanisms of other black silk mourning dresses from 1830-1840 may also provide further clues for understanding the distinctive discolouration of this dress.

7 Conclusion

Queen Victoria's silk dress was weighted and dyed according to the customs of dyeing silk black in the first half of the 19th century. More precisely, it was dyed with the use of logwood and tannin in combination with metal salts. Besides alum, mainly iron but also copper salts were found, resulting from the addition of additives such as green vitriol or Spanish green. Combined with the known history of the dress, this collaborative study confirmed that this dress's discolouration is unique and complex, demonstrating various conditions of logwood-dyed weighted black silks and the difficulties involved in identifying future degradation patterns of the dress. Given the vulnerable nature of the faded silk, a cautious conservation approach needs to be taken, balancing the desire for public access to the dress with the risks inherent in certain environmental conditions. This study provides a basis for further research which will not only benefit the dress's long-term preservation but may also be complementary to further investigations into the deterioration mechanism of logwood-dyed black silks.

8 Acknowledgement

We wish to acknowledge Rufus Bird, Deputy Surveyor of the Queen's Works of Art at The Royal Collection for his support and permission for sampling the silks from the dress and publishing this article. Special thanks are also due to Beatrice Behlen, Senior Curator of Fashion and Decorative Arts, and Sarah Demb, Records Manager, at The Museum of London. A special thanks to Helen Slade, Textile Conservator colleague at HRP, for sharing her experience and knowledge from the recent conservation work with this dress and providing invaluable inputs. Many thanks also to all staff Conservation and Collection Care at HRP. From the IRPA-KIK laboratory, we also want to thank Marie-Christine Maquoi and Alexia Coudray for their very dedicated work.

9 References

1. K. Staniland, *In Royal Fashion: The clothes of Princess Charlotte of Wales and Queen Victoria 1796-1901*, Museum of London, London, 1997, p. 94.

2. K. Staniland, *In Royal Fashion: The clothes of Princess Charlotte of Wales and Queen Victoria 1796-1901*, Museum of London, London, 1997, p. 97.

3. J. Arnold, *Patterns of Fashion 1: Englishwomen's dresses and their construction c.1660-1860*, Macmillan London, London, 1977, 54-55.

4. K. Staniland, *In Royal Fashion: The clothes of Princess Charlotte of Wales and Queen Victoria 1796-1901*, Museum of London, London, 1997, p. 96.

5. K. Staniland, *In Royal Fashion: The clothes of Princess Charlotte of Wales and Queen Victoria 1796-1901*, Museum of London, London, 1997, pp. 15-16.

6. A. Hulme, H. McNab et al., *ICOM 14th Triennial Meeting* The Hague, 12-16 Sept 2005: Preprints vol. II, Earthscan Publications Ltd., London, 2005, p. 783.

7. J. Hofenk de Graaff, The *Colourful Past. Origins, Chemistry and Identification of Natural Dyestuffs*, 2004, pp. 234-235.

8. J. Hofenk de Graaff, The *Colourful Past. Origins, Chemistry and Identification of Natural Dyestuffs*, 2004, p. 298

9. M. Hacke, *Weighted silk: history, analysis and conservation,* Rev. Conserv., 2008, **9**, 3-15.

10. F. Brunello, *The art of Dyeing in the history of mankind*, Neri Pozza Editore (English edition), Vicenza, 1973, pp. 178-179.

11. J. Hofenk de Graaff, The *Colourful Past. Origins, Chemistry and Identification of Natural Dyestuffs*, 2004, pp. 286-289.

12. P. Garside, P. Wyeth, X. Zhang, *Use of Near IR Spectroscopy and chemometrics to assess the tensile strength of historic silk*, e-Preserv. Sci., 2011, **8**, 68-73.

13. P. Garside, P. Wyeth, *Cristallinity and degradation of silk: correlations between analytical signatures and physical condition on ageing*, Appl. Phys. A, 2007, **89**, 871-876.

14. K. Hallett, D. Howel, *Size exclusion chromatography as a tool for monitoring silk degradation in historic tapestries*, in: R. Janaway, P. Wyeth, Eds, *Scientific Analysis of Ancient and Historic Textiles: Informing, Preservation, Display and Interpretation*, Archetype, London, 2005, pp.143-150.

15. I. Vanden Berghe, J. Wouters, *Identification and condition evaluation of deteriorated protein fibres at the sub-microgram level by calibrated amino acid analysis*, in: R. Janaway, P. Wyeth, Eds., *Scientific Analysis of Ancient and Historic Textiles: Informing, Preservation, Display and Interpretation*, Archetype, London, 2005, pp. 151-158.

16. I. Vanden Berghe, *Towards an early warning system for oxidative degradation of protein fibres in historical tapestries by means of calibrated amino acid analysis*, J. Arch. Sci., 2012, **39**, 1349-1359.

17. X. Zhang, I. Vanden Berghe, P. Wyeth, *Heat and moisture promoted deterioration of raw silk estimated by amino acid analysis*, J. Cult. Her., 2011, **12**, 408-411.

18. J. Kim, P. Wyeth, *Towards a routine methodology for assessing the condition of historic silk*, e-Preserv. Sci., 2009, **6**, 60-67.

19. E. Richardson, P. Garside, *The use of Near Infrared Spectroscopy as a diagnostic tool for historic silk artefacts*, e-Preserv. Sci., 2009, **6**, 68-74.

20. J. Kim, X. Zhang, P. Garside, *The inherent characteristics of aged silk*, e-Preserv. Sci. 2008, **5**, 41-46.

21. P. Garside, P. Wyeth, X. Zhang, *The inherent acidic characteristics of silk, part II – weighted silks*, e-Preserv. Sci., 2010, **7**, 126-131

22. J. Neevel, *The development of a new conservation treatment for ink corrosion based on the natural anti-oxidant phytate*, in: M. Koch, J. Palm, Eds., *Preprints 8th International Congress of IADA*, Tübingen, 1995, pp. 93-102.23. The Iron Gall Ink Website, www.ink-corrosion.org (accessed 27/05/2013).

10 Notes

I. B. Behlen, Personal communication via email correspondence of 10 October 2012.

II. S. Demb, Personal communication via email correspondences of 6 & 9 November 2012, suggesting Shepherd, F. *The Treasury of London's Past*, Museum of London, London, 1991 as the source of information.

III. Garside, P., Personal communication via email correspondence, October 2012.