Microscopic Analysis of Historic Textile Fibres Pre- and Post-Cleaning

2020 RMS Summer Studentship Report: Rana Salem,
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Bleaching is a last-resort method used by textile conservators to preserve historic textiles. The process removes stains but can give rise to structural damage on the fibre level. The aim of this research project was to investigate the effects of two bleaching methods on cotton textiles, including a dress-shirt circa. 1900 using various light microscopy operating modes. Cotton samples were supplied that were previously bleached for 24 hours in hydrogen peroxide (oxidative) and sodium borohydride (reductive). The textiles and threads were examined using a digital microscope. Individual fibres were examined with a compound microscope.

Both longitudinal and cross-sectional fibre samples were examined using brightfield, darkfield, polarised light and phase contrast microscopy. Digital microscopic analysis revealed fabric structure and twisting of the threads. It was noticeable that fabric structure was affected by both cleaning methods. Microscopic data from the compound microscope showing longitudinal structure showed surface disruption of the fibre due to bleaching. Cross-sectional analysis was the most revealing. The data indicates the central channel in the cotton (the lumen) is weakening from the inside, leading to the wall fracturing and splitting apart. In conclusion, oxidative and reductive bleaching both have detrimental effects on the integrity of cotton textiles.

Figure 1. Dress shirt (circa. 1900).

Aim

The aim of this project is to assess the effect of oxidative and reductive bleaching methods on cotton fibres from new/historic cotton textiles (*circa.* 1900). The effects were to be assessed namely through digital and compound microscopy, so that various imaging modes could be used to obtain image data.

Method

For this project, raw (loomstate calico), scoured and historic cotton were analysed. The calico was sourced from Whaleys (Bradford) Ltd. The historic cotton (*circa.* 1900, *Figure 1*) was provided by the University of Glasgow's Centre for Textile Conservation.

Oxidative and reductive bleaching solutions were previously prepared using hydrogen peroxide and sodium borohydride respectively. Both solutions were divided among three wide-necked flasks so the samples could be bleached for 15 minutes, 30 minutes, 2 hours and 24 hours.

The instruments used were a digital and compound microscope. The digital microscope (*Figure 2*) was capable of 20-200x magnification, the compound microscope (*Figure 3*) was fitted with objectives

Figure 2. Celestron Handheld Digital Microscope PRO

Figure 3. Leica DM750

from 4-100x magnification and capable of brightfield, darkfield, polarised light and phase contrast imaging. Both systems included cameras.

Samples analysed via digital microscopy were prepared by extracting a single thread and mounting onto a microscope slide using sellotape. Longitudinal fibre samples were prepared by tweezing an individual fibre from the sample and dry/wet mounting onto a slide. The cross-sectional samples (1µm thick) were provided by the University of Glasgow's Electron Microscopy Unit.

Results

The data from this project consisted of images captured using the digital and compound microscope. Images produced from the digital microscope provided information regarding structural integrity of the cotton threads pre- and post-cleaning. Concerning the historic textile, *Figure 4* shows images of threads from the historic dress shirt pre- and post-cleaning.

In pre- and post-cleaning, *Figure 4* shows signs of the fibres unwinding from the thread itself. This is to be expected, especially pre-cleaning as the shirt is believed to have originated *circa.* 1900, it would have been washed and potentially bleached when in use. As the degree of fibre unwinding also appears in both the oxidatively and reductively bleached sample, it is difficult to determine the extent that the bleaching methods alone contributed to any damage seen in the centre and right-hand side images shown in *Figure 4*.

In *Figure 5*, cross-sectional brightfield images were taken with the compound microscope. Cross-sectional analysis provides the most information, revealing how bleaching affects not just the surface structure, but internal structure also. In *Figure 5*, the unclean cross-section has a kidney-bean shape with a visible lumen. In comparison, the oxidatively bleached cross-section shows visible change in

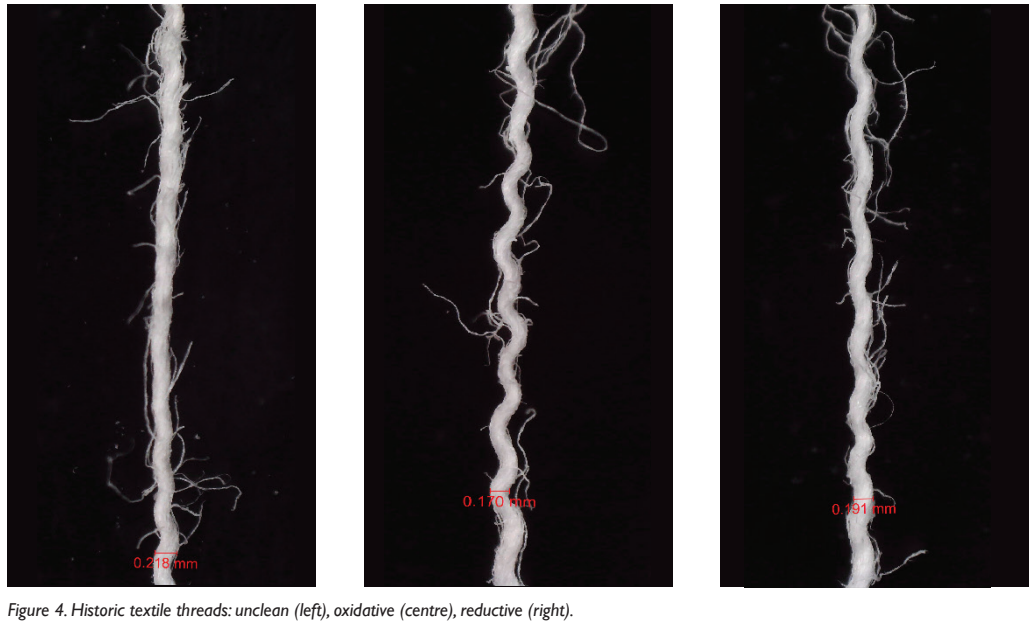

Figure 4. Historic textile threads: unclean (left), oxidative (centre), reductive (right).

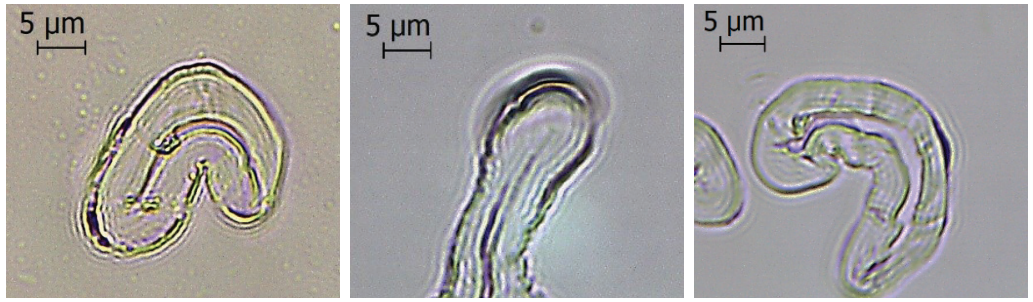

Figure 5. Historic textile cross-sections: unclean (left), oxidative (centre), reductive (right) - 100x.

structure where it is fully extended instead of folded as with the unclean cross-section. Lastly, the right-hand side image shows reductively cleaned cotton. Two noticeable changes are that the lumen appears to have expanded when compared to the left-hand side and centre images. The kidney-bean shaped structure also appears less obvious compared to the unclean cross-section.

Digital and compound microscopy are extremely useful tools which, when used together, provide a lot of information at the thread/fibre level. In particular, the two methods allow the analyst to examine the extent of structural degradation that may have occurred as a result of bleaching.

Illustrated in Figure 5, oxidative and reductive bleaching affected the cross-sectional structure of cotton in differing ways, making it challenging to conclusively state which is more damaging than the other.

Experience

A major skill I learned upon completing this project was how to comfortably manipulate the imaging modes/optical settings on the compound microscope. From continual practice and positive feedback from my supervisors, I feel more confident in my ability to capture high-quality images via optical microscopy.

My practical work has made me more appreciative of the microscope as an analytical instrument. Additionally, due to circumstances in which this project took place (social distancing), I have also developed a deeper respect for working in adverse conditions and highly value the support of my supervisors throughout this project.

Future Considerations

In future, I am keen to expand upon the data which I have collected for this project. Namely, I would consider gaining experience with techniques such as scanning electron microscopy and atomic force microscopy so that those skills can be applied and contribute to this project.

As my experience of this project was wholly positive, it has solidified my decision to pursue microscopy further in the form of post-graduate study (MSc). I am also eager to apply to do future projects similar to the RMS summer studentship. Since I am currently studying as a forensic investigation student, I am now more interested in taking on a career path in microscopy through the route of forensic examination work.

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To find out more about Rana's project, check out her recent webinar at www.rms.org.uk