An Investigation into Conservation Treatment Methodologies for *Golden Tangram*, a Lucienne Day silk mosaic

By Kim Tourret

Submitted in partial fulfilment of the requirements for the Degree of Master of Philosophy in Textile Conservation in the School of Culture and Creative Arts, University of Glasgow,

August 2018

Word count: 15,009

Abstract

An investigation was undertaken to develop a methodology to treat *Golden Tangram,* a Lucienne Day silk mosaic mounted on a backing board with what is now very degraded adhesive. The client brief was to identify the adhesive and recommend a method to remove it.

A literature review of adhesive identification and removal and the cleaning of multi-layered textiles was undertaken. Solubility testing and FTIR analysis were used to characterise the adhesive, which was most likely cellulose-nitrate based. This could continue to deteriorate and degrade *Golden Tangram* so removal was recommended.

Removal methods tested included immersion, using a vacuum suction table, and different poultices. A poultice method was developed that allows for soiling to be 'feathered out' without using a transparent poultice medium. Two treatment options were proposed: 1) using the 'feathering' poultice technique, and 2) using the same technique followed by immersion cleaning.

The construction of multi-layered textiles affects the direction of the solubilised soiling - patchwork construction promotes movement through the layers rather than laterally. Both immersion and poultice treatments can be suitable for multi-layered textiles, but vacuum suction tables are less suitable due to the lack of contact time with the solvent and potential for distortion.

Acknowledgments

I would like to firstly thank my dissertation supervisor, Karen Thompson, for her advice, support and patience, and Dr Margaret Smith for guiding me through the FTIR analysis. I also owe a big thanks to Ann French and Jennifer Harris from the Whitworth Art Gallery for all of their help throughout this project. Finally, I am incredibly grateful to Paula Day who very kindly answered all of my questions and gave me new insights into *Golden Tangram*.

<u>Contents</u> **Page**

List of Figures

Page

List of Tables — **Page**

Chapter 1: Introduction

1.1 Introduction

This dissertation focuses on an in-depth investigation into the development of a treatment methodology for one particular object – *Golden Tangram,* a Lucienne Day silk mosaic which is part of the Whitworth Art Gallery's collection.

The treatment will be specifically tailored because *Golden Tangram* is a piece of contemporary art and because of the object type – *Golden Tangram* has multiple layers of different materials, making treating it a much more complex problem. The methodology developed will allow for the object to be treated safely at a later day and with the stakeholders' wishes in mind. The results of the research undertaken will be reviewed and conclusions drawn that will add to the currently limited information and case studies on the cleaning of multi-layered textiles.

1.2 *Golden Tangram*

Golden Tangram is one of many silk mosaics designed by Lucienne Day from the mid-1970s until her retirement in 1999. It was recently donated by Paula Day, Lucienne Day's daughter, to the Whitworth Art Gallery. It has been constructed using a traditional paper-piecing patchwork technique to create a design from hundreds of multi-coloured silk pieces, and then been backed with a fusible lining and the edges bound. At some point it was mounted on to a painted MDF backboard by Day's husband, Robin Day, using an unknown adhesive. It is in good condition overall, but the adhesive used to mount it has severely degraded, losing its adherent properties, yellowing and becoming hard and brittle.

1.3 Client brief

The brief from the Whitworth Art Gallery consists of three main elements. Firstly, to identify the type of adhesive used to mount *Golden Tangram* on the MDF backing board. Secondly, to remove this adhesive and the associated staining which has been caused by its degradation. Finally, to re-mount *Golden Tangram* back on to the original MDF backing board, but to conservation standards.

This dissertation will focus on the first element of the brief – identifying the adhesive – and develop a methodology to allow the second part of the brief – removing the adhesive – to be completed at a later date.

1.4 Research methodology

The practical research methodology will be guided by the client brief for the object's treatment.

1.4.1 Characterising the adhesive

Given the huge range of adhesives that have been and are available on the market, and how poorly the adhesive has degraded, it may not be possible to identify the precise adhesive that was used. However, characterising the adhesive and identifying the broader type of adhesive that has been used will help to predict its future stability which will inform how to reduce or remove the staining.

Research into adhesive identification will be used to select methods with which to identify or characterise the adhesive. The results of these methods will be combined to form a conclusion as to what type of adhesive was used to mount *Golden Tangram*. However, it must be taken into account that the adhesive on the object has degraded and likely chemically altered from its original structure. It is therefore likely that results from the identification tests could be complex and not easily resolved.

1.4.2 Treating the adhesive

The main treatment aim is to remove the adhesive stain at the front of the *Golden Tangram* as requested by Paula Day, who donated it to the Whitworth. However, the adhesive staining is most noticeable on the back of the object. Whether removal beyond the front stain will be necessary will be determined by the results of the adhesive analysis which will inform if the adhesive is relatively stable at this point or will continue to degrade the object.

Once the extent of the adhesive removal has been established, the eventual method recommended will depend on several factors.

1. What substance will remove the staining without damaging the textile? There are risks that will need to be considered when finding a substance to remove the

staining. Solvents, which are usually used to remove adhesives, can be very drying to textiles and can be quite toxic.

2. What method of cleaning is most suitable and can be used on a multi-layer and possibly multi-media object? The fact that the object is multi-layered makes even basic stain removal more complex, especially if the adhesive is not stable and needs to be removed as much as possible. The movement of the adhesive through the various layers and controlling this will need to be considered.
3. What method is workable considering the resources and equipment at the Whitworth Gallery? The developed methodology needs to be able to be implemented at the Whitworth.

Once potential methods have been identified, they will be tested using mock-ups that will resemble the object as closely as possible in materials and construction. This way methods can be tested and evaluated without causing any harm to the object.

1.5 Aims and objectives

There are two primary aims which will be achieved by completing the following objectives.

Aim 1: To enable the future fulfilment of the brief given by the client by: 1) Characterising the adhesive in order to predict its future stability and therefore inform how and to what extent it should be reduced or removed, and 2) Investigating and evaluating different methods of reducing or removing the adhesive to determine which is most suitable in terms of effectiveness, efficiency in practice, and risk to the object's safety. Given *Golden Tangram's* complex multi-layered structure, there are more potential risks to consider regarding the treatment.

Objectives:

- Review past research on the identification of adhesives to identify suitable methods for use on the *Golden Tangram* adhesive.
- Undertake visual and instrumental analysis of the adhesive, as determined by the previous research.
- Conduct a full examination and complete an object report and condition record of the object to help determine what conservation treatment is necessary.

- Review methods of adhesive removal in textile conservation and cleaning multi-layered textiles to identify potential methods that could be tested for use on *Golden Tangram.*
- Create mock-ups of *Golden Tangram* with which to test potential treatment methods.
- Evaluate the results of the treatments on the mock-ups and propose a suitable method or methods for use on the object.

Aim 2: To contribute to the limited information and research on stain removal from multi-layered textiles.

Objectives:

- Consider the different factors in cleaning multi-layered textiles to review how different methods may suit particular objects.
- Evaluate all methods tested for use on *Golden Tangram* with consideration to how they may be utilised on other multi-layered textiles with the previously reviewed factors in mind.

Chapter 2: Literature Review

2.1 Introduction

This literature review aims to directly inform the practical aspects of the project's methodology: 1) A review of research into adhesives in general and their identification will guide the characterisation of the adhesive, and 2) Research into past instances of adhesive removal in textile conservation and stain removal on multi-layered textiles will inform which methods will be tested for eventual use on *Golden Tangram*. While not specific to the dissertation aims, a literature review on the conservation of contemporary textile art was also undertaken (see Appendix 1).

2.2 Adhesives

There are numerous sources regarding adhesives – this review will be limited to those focused on materials conservation.

Two key texts regarding adhesives in conservation are Down's *Adhesive Compendium for Conservation* and *Materials for Conservation: Organic Consolidants, Adhesives and Coatings* by Horie.[1, 2] Both contain good general information on different categories of adhesives, their stability and general degradation pathways. Both focus mainly on adhesives used in conservation treatments and their benefits and drawbacks. Down gives suggestions where one might find similarly based adhesives outside of conservation, but this information is limited.

Down's compendium contains a textile section,[3] but a better textile-specific source is the adhesives section in *Chemical Principles of Textile Conservation*.[4] While this gives better information on how textile properties need to be considered when using adhesives there is still little information beyond that provided by Down regarding identifying or removing adhesives.

[1] Jane L. Down, *Adhesive Compendium for Conservation* (Ottawa: Canadian Conservation Institute, 2015).
[2] Velson Horie, *Materials for Conservation: Organic Consolidants, Adhesives and Coatings*, 2nd ed. (Abingdon: Routledge, 2010).
[3] Down, 149.
[4] Ágnes Tímár-Balázsy and Dinah Eastop, *Chemical Principles of Textile Conservation* (Oxford: Butterworth-Heinemann, 1998), 304.

2.2.1 Adhesive Identification

The most common method of identification found in the literature was solubility tests. Based on the idea of 'like dissolves like', identifying solvents that solubilise the adhesive can determine the solubility parameters of the adhesive itself.[5] The recommended method was the use of Tea's solubility parameters and triangular chart (used to plot the ratio of dispersion, polar and hydrogen bonding forces).[6] Using Hansen's multi-parameters gives more accurate results, but, as these need to be plotted on a sphere, Tea's chart is more functional in practical terms.[7]

It is noted that solubility tests are not totally reliable, given unpredictable factors such as non-random hydrogen-bonding, the amorphous/crystalline ratio of the solute, and the presence of ionic materials that may all alter solubility.[8] In addition, smaller solvent molecules are more likely to dissolve an adhesive than their position on a Tea's chart would indicate, and smaller adhesive molecules have a larger region of solubility.[9] Organic adhesives also become more polar with age, and thus solubility results may be different than expected.[10]

Horie suggests using Fourier-transform infrared spectroscopy (FTIR) as a non-destructive method of identification. However, this method requires known sample spectra for comparison, so some prior identification is required. Also, the natural ageing of polymers and any additives in the adhesive can complicate results by giving different results to modern equivalents and giving misleading positive results respectively.[11]

In the case studies reviewed, FTIR is most commonly used to characterise and identify adhesives. Most of these studies were conservation-based, but also included sources regarding polymer science, optics and phototonics, hazardous materials, molecular structure

[5] Down, 5.
[6] Ibid., 8.
[7] Horie, 72.
[8] Down, 8.
[9] Horie, 73.
[10] Julia Carlson, "A Sticky Situation: A Different Method for Removing Adhesive from an Early 17th-Century Carpet," in *ICOM-CC 18th Triennial Conference Preprints, Copenhagen, 4-8 September 2017*, ed. J. Bridgland (Paris: International Council of Museums, 2017), 4.
[11] Horie, 58.

and biomedical materials.[12, 13, 14, 15, 16] While some case studies in textile conservation do use FTIR for adhesive analysis, they do not explain the FTIR process/analysis and are therefore not included in this portion of the literature review.

Of the 13 FTIR adhesive analysis case studies reviewed, the majority utilise FTIR to study known adhesives' degradation pathways,[17, 18, 19, 20, 21, 22, 23, 24] with only five using it to characterise unknown adhesives.[25, 26, 27, 28, 29] Thus, while there is plenty of information available on specific adhesives and their degraded FTIR spectra, if one wants to characterise an unknown adhesive, some prior identification of the adhesive is helpful in order to find the most useful sources.

---

[12] P. Dole and J. Chauchard, "Thermooxidation of Poly(Ethylene-Co-Methyl Acrylate) and Poly(Methyl Acrylate) Compared to Oxidative Thermal Aging of Polyethylene," *Polymer Degradation and Stability* 53, no. 1 (1996): 63–72, accessed June 7, 2018, DOI: 10.1016/0141-3910(96)00026-2.
[13] David C. Miller et al., "Durability of Poly(Methyl Methacrylate) Lenses Used in Concentrating Photovoltaic Modules," *Preprint of Conference Paper to be presented at SPIE 2010 Optics and Photonics Conference, San Diego, California, August 1-5, 2010* (US Department of Energy, 2010), accessed June 7, 2018, DOI: 10.1117/12.861096.
[14] Sebastien Berthumeyrie et al., "Photooxidation of Cellulose Nitrate: New Insights into Degradation Mechanisms," *Journal of Hazardous Materials* 272 (2014): 137–47, accessed June 7, 2018, DOI: 10.1016/J.JHAZMAT.2014.02.039.
[15] Janina Zięba-Palus, Sabina Nowińska and Rafał Kowalski, "Application of Infrared Spectroscopy and Pyrolysis Gas Chromatography for Characterisation of Adhesive Tapes," *Journal of Molecular Structure* 1126 (2016): 232–239, accessed March 18, 2018, DOI: 10.1016/j.molstruc.2015.11.050.
[16] Wayne Nishio Ayre, Stephen P. Denyer, and Samuel L. Evans, "Ageing and Moisture Uptake in Polymethyl Methacrylate (PMMA) Bone Cements," *Journal of the Mechanical Behavior of Biomedical Materials* 32 (2014): 76–88, accessed June 7, 2018, DOI: 10.1016/J.JMBBM.2013.12.010.
[17] Ayre, Denyer and Evans.
[18] Berthumeyrie et al.
[19] Dole and Chauchard.
[20] Suzanne Quillen Lomax and Sarah L. Fisher, "An Investigation of the Removability of Naturally Aged Synthetic Picture Varnishes," *Journal of the American Institute for Conservation* 29, no. 2 (1990): 181, accessed June 7, 2018, DOI: 10.2307/3179582.
[21] Miller et al.
[22] Daina Ragauskien et al., "Long-Term and Accelerated Ageing of an Acrylic Adhesive Used as a Support for Museum Long-Term and Accelerated Ageing of an Acrylic Adhesive Used as a Support for Museum Textiles" *Studies in Conservation* 51, no. 1 (2006): 57–68, accessed June 7, 2018, http://www.jstor.org/stable/20619425.
[23] Donald Sale, "Yellowing and Appearance of Conservation Adhesives for Poly(Methyl Methacrylate): A Reappraisal of 20-Year-Old Samples and Test Methods," in *Proceedings of Symposium 2011: Adhesives and Consolidants for Conservation* (Ottawa: CCI, 2011).
[24] Y. Shashoua, S. M. Bradley, and V. D. Daniels, "Degradation of Cellulose Nitrate Adhesive," *Studies in Conservation* 37, no. 2 (1992): 113-119, accessed June 11, 2018, DOI: 10.2307/1506403.
[25] Andrea Gorassini et al., "ATR-FTIR Characterization of Old Pressure Sensitive Adhesive Tapes in Historic Papers," *Journal of Cultural Heritage* 21 (2016): 775–85, accessed March 18, 2018, DOI: 10.1016/j.culher.2016.03.005.
[26] Tom Learner, "The Analysis of Synthetic Resins Found in Twentieth Century Paint Media," in *Resins Ancient and Modern: Pre-Prints of the SSCR's 2nd Conference Held at the Department of Zoology, University of Aberdeen, 13 - 14 September 1995*, ed. Margot M. Wright and Joyce Townsend (Edinburgh: SSCR, 1995), 76–84.
[27] P. Nel et al., "Analysis of Adhesives Used on the Melbourne University Cypriot Pottery Collection Using a Portable FTIR-ATR Analyzer," *AICCM Bulletin* 30 (2007): 27-37, accessed June 11, 2018, DOI: 10.1016/j.vibspec.2010.01.005.
[28] Emily Noake, Deborah Lau, and Petronella Nel, "Identification of Cellulose Nitrate Based Adhesive Repairs in Archaeological Pottery of the University of Melbourne's Middle Eastern Archaeological Pottery Collection Using Portable FTIR-ATR Spectroscopy and PCA," *Heritage Science* 5, no. 3 (2017), accessed June 11, 2018, DOI: 10.1186/s40494-016-0116-z.
[29] Zięba-Palus, Nowińska, and Kowalski.

When reviewing past textile conservation treatments where adhesives were removed, both solubility testing and FTIR have been used to identify the adhesives.[30, 31] Other methods of identification included starch and protein tests,[32, 33] scanning electron microscopy (SEM),[34] and pyrolysis-gas chromatography/mass spectrometry.[35] However, these are rarely explained and, while some methods, i.e. starch and protein tests, are somewhat self-explanatory, it can be unclear why others have been chosen.

2.2.2 Adhesive removal

Down's compendium provides the best general guide to adhesive removal, with information given on the most common methods, including using mechanical action, heat, solvents and enzymes.[36] Different application methods for solvents are introduced, including gels, poultices and immersion. However, this is not material-specific. *Chemical Principles of Textile Conservation*, while including a chapter on the application of conservation adhesives, has very little information on removing adhesives or consolidants from textiles and focuses mainly on the principles behind removing old adhesive treatments with little practical information.[37]

As well as these general texts, seven case studies where adhesives have been removed in textile conservation treatments were also reviewed (see Table 1).

[30] Carlson, 2.
[31] Mary W. Ballard, "The Removal of Crosslinked Synthetic Latex from Carpets: Preliminary Results," in *ICOM-CC 8th Triennial Meeting, Sydney, Australia 6-11 September 1987, Preprints*, ed. Kirsten Grimstad and JoAnn Hill (International Council of Museums, 1987), 332.
[32] Mary Westerman Bulgarella and Susanna Conti, "The Conservation of Savonarola's Painted Banner," in *Tales in the Textile: Preprints: North American Textile Conservation Conference 2003* (Albany, 2003), 140.
[33] Lynn McClean and Elizabeth-Anne Haldane, "Avendale for Reformation: Conservation of a 17th Century Covenanting Banner," in *Tales in the Textile: Preprints: North American Textile Conservation Conference 2003* (Albany, 2003), 146.
[34] Alison Chester and Dinah Eastop, "The Problem of Common Solubility Parameters: The Removal of Natural Rubber Adhesive Residues from a Painted Silk Banner," in *Resins Ancient and Modern: Pre-Prints of the SSCR's 2nd Conference Held at the Department of Zoology, University of Aberdeen, 13 - 14 September 1995*, ed. Margot M. Wright and Joyce Townsend (Edinburgh: SSCR, 1995), 48.
[35] Carlson, 2.
[36] Down, 27-29.
[37] Tímár-Balázsy and Eastop, 324-325.

Table 1 – Adhesive removal case studies

Case Study	Adhesive	Object	ID Method	Cleaning Method	Comments
Ballard, Mary W. “The Removal of Crosslinked Synthetic Latex from Carpets: Preliminary Results.”	Latex but exact polymer unidentified - repair treatment	Carpets	Solubility tests, XRF and IR (not conclusive)	Rinsed in 10% ammounium acetate	Chosen for pH and appearance of test sample after treatment and appearance of test solution.
Carlson, Julia. “A Sticky Situation: A Different Method for Removing Adhesive from an Early 17th-Century Carpet.”	Mix of natural rubber and a triterpenoid resin - applied mid 20th century	Carpet - silk warp, cotton weft, wool pile	FTIR and pyrolysis-gas chromatography/mass spectrometry	Plain 2% agarose used to swell adhesive then removed mechanically; Darker more aged needed 2% xanthan gel (pH 9) with acetone/ethanol (1:1) - textile then rinsed with deionised water and blotted dry and adhesive removed with vacuum.	Alkaline xanthan chosen to counteract acidity of fibre degradation and adhesive.
Chester, Alison, and Dinah Eastop. “The Problem of Common Solubility Parameters: The Removal of Natural Rubber Adhesive Residues from a Painted Silk Banner.”	Natural rubber, organic resins and zinc oxide filler - residue from a pressure sensitive adhesive	Painted silk banner	SEM coupled to an X-ray microprobe and nuclear magnetic resonance spectroscopy	Genklene dropped on to banner, using suction table and filter paper to manage movement of adhesive.	Poultices tested but found to cause tide marks
Heuman, Jackie, and Kate Garland. “A Poultice Technique for the Removal of Cellulose Nitrate Adhesive from Textiles.”	Cellulose nitrate	Silk satin textile with 2 cellulosic linings	Not noted.	Adhered lining fabric removed by placing textile on acetone soaked blotting paper and covering with polyethene. After two hours, adhesive soft enough to peel off lining. Residue removed with 1:2 sepiolite:acetone poultice sandwiched with blotting paper, muslin and polythene.	Heat not effective on residue and acetone drove it further into the fibres.
Marouf, Mohamed, and Medhat Sabers. “Removal of Some Old Resins from Ancient Pile-Textiles: An Applied Study on a Turkish Rug.”	Animal glue	Prayer rug - cotton warp and weft, wool pile	Not noted.	Submerged in dimethyl formamide and adhesive mechanically removed with soft brushes. Followed by wet clean in Orvus with 1% SCMC.	
McClean, Lynn, and Elizabeth-Anne Haldane. “Avendale for Reformation: Conservation of a 17th Century Covenanting Banner.”	Animal glue and starch mixture - old repairs. Small amount of synthetic.	Painted silk banner	Starch and protein tests. Synthetic adheisve not analysed.	Adhesive swabbed off with water and blotted from both sides. Goretex poultice used on area of more starch. Alpha amylase applied locally with Albertina Kompress. Did need rinsing afterwards.	Method not recommended for object that cannot be wet cleaned. Small amount of synthetic adhesive released with acetone.
Westerman Bulgarella, Mary, and Susanna Conti. “The Conservation of Savonarola’s Painted Banner.”	Vegetable paste	Linen banner with silk trim	In footnotes - starch presence and solubility in water.	Removed mechanically with scalpel under magnification. Staining removed with wet cleaning with distilled water on vacuum suction table.	No issue of layers

Horie notes that identifying the adhesive is important when choosing a methodology to remove it.[38] However, in the majority of case studies, initial identification is not fully explained. The exception is Ballard's case study on the removal of synthetic latex from carpets, which gives a detailed explanation of the methods used and the results analysis.[39] This general lack of information on this aspect of the treatment may be due a desire to focus on the treatment itself, but could also have been limited by the experience and knowledge of the authors and the analytical techniques available to them.

Five of the seven case studies involved use of an organic solvent or another volatile chemical substance to remove the adhesive (see Table 1). Consequently, several of the sources note that health and safety need to be considered when using solvents and other volatile substances.[40, 41, 42, 43]

Solubility of the degraded adhesive is also commonly discussed and three of the case studies mention the use of solubility tests.[44, 45, 46] Carlson and Ballard use this method to find the least polar 'poor' solvent that will be able to break the adhesive bond, but not promote movement of the adhesive.[47, 48] Carlson also notes, as Down does, that organic adhesives will become more polar with age, thus requiring more polar solvents.[49]

The methods used to remove the adhesives in the case studies are quite varied and depend on the adhesive and object type (see Table 1). The authors will have had different facilities and resources available to them, and will also have been subject to different health and safety measures. Methods used included immersion of the object and using a vacuum suction table to control the movement of the solvent.[50, 51, 52] Three case studies used localised poultice treatments for various reasons, including the contact time needed for the

---

[38] Horie, 58.
[39] Ballard, 333-334.
[40] Carlson, 3.
[41] Chester and Eastop, 49.
[42] Jackie Heuman and Kate Garland, "A Poultice Technique for the Removal of Cellulose Nitrate Adhesive from Textiles," *The Conservator* 11, no. 1 (1987): 30, accessed June 12, 2018, DOI: 10.1080/01410096.1987.9995023.
[43] Mohamed Marouf and Medhat Sabers, "Removal of Some Old Resins from Ancient Pile-Textiles: An Applied Study on a Turkish Rug," in *The Textile Speciality Group Postprints of the AIC 37th Annual Meeting*, ed. Joel Thompson et al. (AIC, 2009), 123.
[44] Carlson, 4.
[45] Chester and Eastop, 49.
[46] Ballard, 332.
[47] Ibid., 332.
[48] Carlson, 4.
[49] Ibid., 4.
[50] Ballard, 335.
[51] Marouf and Sabers, 123.
[52] Chester and Eastop, 49-50.

solvent to break the adhesive bonds, the localised nature of the treatment, the need to minimise the risk of dye bleed, and where immersion was not possible due to the size of the solvent bath required.[53, 54, 55] Two poultice treatments left residues and needed to be followed by wet cleaning.[56, 57] Several of the case studies utilised mechanical action as part of the treatment.[58, 59, 60, 61]

The majority of the case studies appear to analyse the results of the treatment through visual analysis alone. Other methods used were enhancing visual analysis by adding a colourant to the test adhesive,[62] and using X-ray fluorescence (XRF) to identify chemical elements present before and after the treatment.[63] However, justification of these methods and the conclusions formed as a result are limited.

2.3 Cleaning multi-layers textiles

Separating the layers of *Golden Tangram* to facilitate the treatment is not possible due to its construction and its good condition. Therefore, this review of cleaning multi-layered textiles is limited to treatments that do not involve the separation of the layers, with the object being left intact throughout the process. Only three such case studies were found.

All case studies involved the cleaning of quilts, which present structural similarities to *Golden Tangram*, with several layers and stitching throughout the object, rather than just at the edges. Two of the case studies involved treatment of the whole object as the soiling was extensive, although these were undertaken very differently due to the different type of soiling.[64, 65] The last case study utilised a localised cleaning method to control the movement of a water-soluble dye.[66]

---

[53] Carlson, 3.
[54] Heuman and Garland, 30.
[55] McClean and Haldane, 148.
[56] Carlson, 6-7.
[57] McClean and Haldane, 149.
[58] Carlson, 6.
[59] Marouf and Sabers, 123.
[60] McClean and Haldane, 147.
[61] Westerman Bulgarella and Conti, 137.
[62] Heuman and Garland, 31.
[63] Marouf and Sabers, 121.
[64] James W. Rice, "An Heirloom Patchwork Quilt and Its Conservation Problems," *Studies in Conservation* 11, no. 1 (1966): 4–5, accessed January 21, 2018, DOI: 10.1179/sic.1966.001.
[65] Christina Ritschel, "The Conservation of the E Dickins Quilt," *AICCM Bulletin* 32, no. 1 (2011): 205-206, accessed January 21, 2018, DOI: 10.1179/bac.2011.32.1.025.
[66] Shirley Ellis, "Disaster Recovery at the University of Alberta, or, Every Flood has a Silver Lining," *Journal of the American Institute for Conservation* 39, no. 1 (2000): 124, accessed July 1, 2018, DOI: 10.1179/019713600806113365.

2.4 Conclusion

There is plenty of information on adhesives in general, but a lack of information on commercial adhesives which makes the identification of a modern degraded non-conservation adhesive difficult. This is likely due to a lack of disclosure on their contents by the manufacturers, and the difficulty in identifying adhesives once they have degraded. The more general texts, such as Down and Horie, are a good starting point, as looking at the likely degradation pathways and physical properties of adhesive can give an initial indication of what the adhesive might be. However, to narrow this down further, one would need to look further afield into studies of specific adhesives.

The most common methods used to identify or characterise adhesives - solubility testing and FTIR analysis - seem most suitable for use in this project and are recommended in Horie and Down's guides. However, neither method is totally reliable, and one must be aware of the factors that can affect the results when using them for analysis. The degradation of the adhesive is likely to add complexity to results, and suitable case studies will need to be used to find spectra of known aged adhesives for comparison. These can potentially be found in case studies using FTIR analysis on adhesives, but, as per the general adhesive sources, these usually only pertain to one specific adhesive, so some prior identification is required to find suitable sources. The commercial nature of the adhesive is also likely to make analysis more difficult as unknown additives could affect the results.

The methods that can be used to remove adhesives from textiles are very varied, each with their own drawbacks and benefits that make them suitable for particular adhesives or objects. The most commonly used treatments are immersion, poultices and vacuum suction, sometimes aided by mechanical action. Only three of the case studies involve removing modern synthetic adhesives rather than older natural glues, and, in one of these cases, the adhesive was removed with no attempt at identification. The method used is not necessarily affected by the adhesive being natural or synthetic, but unlike several natural glues, i.e. starch and animal glues, synthetics are not usually soluble in water, and the substances required to solubilise them need additional consideration when forming a methodology. The adhesive on *Golden Tangram* will likely require an organic solvent to solubilise it, so health and safety precautions will need to be considered. However, as *Golden Tangram* is relatively small, more options will be possible than for larger objects where the solvent quantities required would not be desirable.

Finally, the review has showed there is a lack of recorded treatments of multi-layered textiles where the object was not deconstructed. The available case studies provide limited information as the treatments are very specific to the types of soiling and the object materials. They suggest that if soiling is extensive, an overall treatment may be more suitable, but there are different methods of carrying this out, and several factors need to be considered, such as dye bleed and cleaning solution. However, they all rely on complete solubilisation of the soiling/staining, and so finding a solvent to do this for the *Golden Tangram* adhesive is very important.

Chapter 3: *Golden Tangram*

3.1 Introduction to *Golden Tangram*

There is limited information available on the history of *Golden Tangram.* It is not even included in the list of silk mosaics from the Lucienne Day Archives.[67] However, it was featured on the cover of the January 2009 issue of *Wallpaper** Magazine as a limited-edition cover. There is no reason to assume that it was made in a different way to the other mosaics, and it was likely made by Karin Conradi, who worked for Day until her retirement in 1999.[68] The original purpose of the design is unknown, but is was likely made for an exhibition and then not sold – it was hung at the top of the stairs of Lucienne and Robin Day's Chichester home.[69] At some point it was mounted on to its painted MDF backing board by Robin Day. This mounting technique was used by Robin Day on several other mosaics, although he devised a number of mounting systems for them over the years.[70] Please see Appendix 2 for more information on Lucienne Day and her silk mosaics.

3.2 Object record

3.2.1 Object description

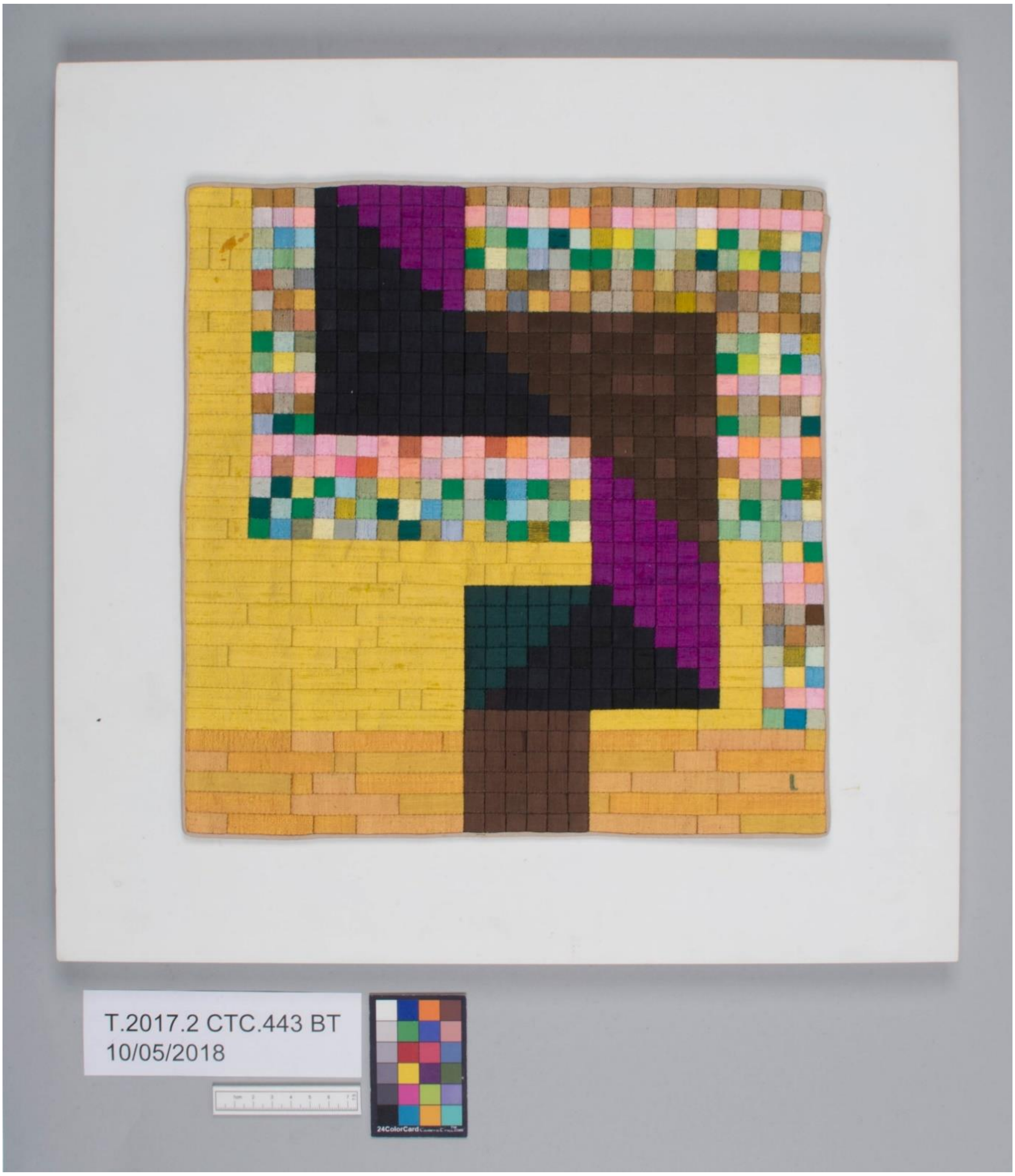
A silk mosaic designed by Lucienne Day that consists of different coloured silk pieces stitched together using traditional paper piecing methods. It has been lined with a white heat fused synthetic material, possibly Vilene®,[71] and the edges bound with peach cotton bias tape. It has been adhered to a painted white MDF backing board with an unknown adhesive.

3.2.2 Orientation and dimensions

Orientated as per Figure 1.
Silk mosaic only 329mm x 325mm x 3mm (H x W x D)
MDF board only 458mm x 459mm x 24mm (H x W x D)

[67] Lesley Jackson, *Robin and Lucienne Day: Pioneers of Contemporary Design* (London: Mitchell Beazley, 2001), 187-188.
[68] Paula Day, questionnaire by Kim Tourret, July 18, 2018.
[69] Ibid.
[70] Ibid.
[71] Now Vlieseline®.

Figure 1 – Overall front of *Golden Tangram*



Design © The Robin and Lucienne Day Foundation

3.2.3 Materials and construction[72]

The design on the front consists of 706 silk squares and rectangles, each approximately 10mm high. The warps and wefts vary in size between the different colours, with

[72] All materials identified through visual analysis.

approximately 26-49 of the wider vertical warp threads and 39-49 of the narrower horizontal weft threads per cm (all Z-twist). The majority of the silk pieces are a bright golden yellow. There is a geometric design motif using brown, navy, black and purple silks, which is surrounded by areas consisting of differently coloured 10mm x 10mm squares. There are 61 different coloured silks used, most of which are shot silks, containing different coloured warp and weft threads. There is one colour with two different coloured wefts and a different colour warp, and nine plain silks with the same coloured warps and wefts.

Each silk piece has been folded around a graph paper template and tacked into place.[73] These have been hand whip stitched together along the folded edges using nine different colours of cotton thread. Thread colours have been chosen to match the colours of the silk. Once stitched together, the tacking threads were removed. Near the bottom right corner, green thread has been used to embroider a monogram 'L', which is the signature Lucienne Day used on her silk mosaic designs.

The back of the mosaic has been lined with a synthetic spun bond material which appears to be heat fused and similar to Vilene®. This has been done in rectangular patches which are aligned with the edges of the mosaic and overlap each other to varying degrees (see Figure 3). The mosaic edges were bound using a peach colour bias binding (Z-twist, 13epcm, 13ppcm). This has been turned under on the front and slip stitched with matching cotton thread and left with a raw edge on the back which has been secured with a running stitch.

The mosaic was adhered to a back board which had been painted white (paint type unknown) on the front and sides only. The backboard is made from MDF and has been hollowed out with a 17mm deep indentation 50mm from the edges. There are two metal picture hooks, one each side of the indentation, as well as drilled holes.

3.2.4 Additional notes

The mosaic was approximately two-thirds detached from the MDF board. After obtaining permission from the client, it was fully detached from the board using gentle mechanical action with a small scalpel. This was done in order to fully document and examine the back of the mosaic where the majority of the degradation was.

[73] Andrew Casey, *Lucienne Day : In the Spirit of the Age* (Woodbridge: Antique Collectors' Club, 2014), 232.

Figure 2 – Overall front construction and soiling

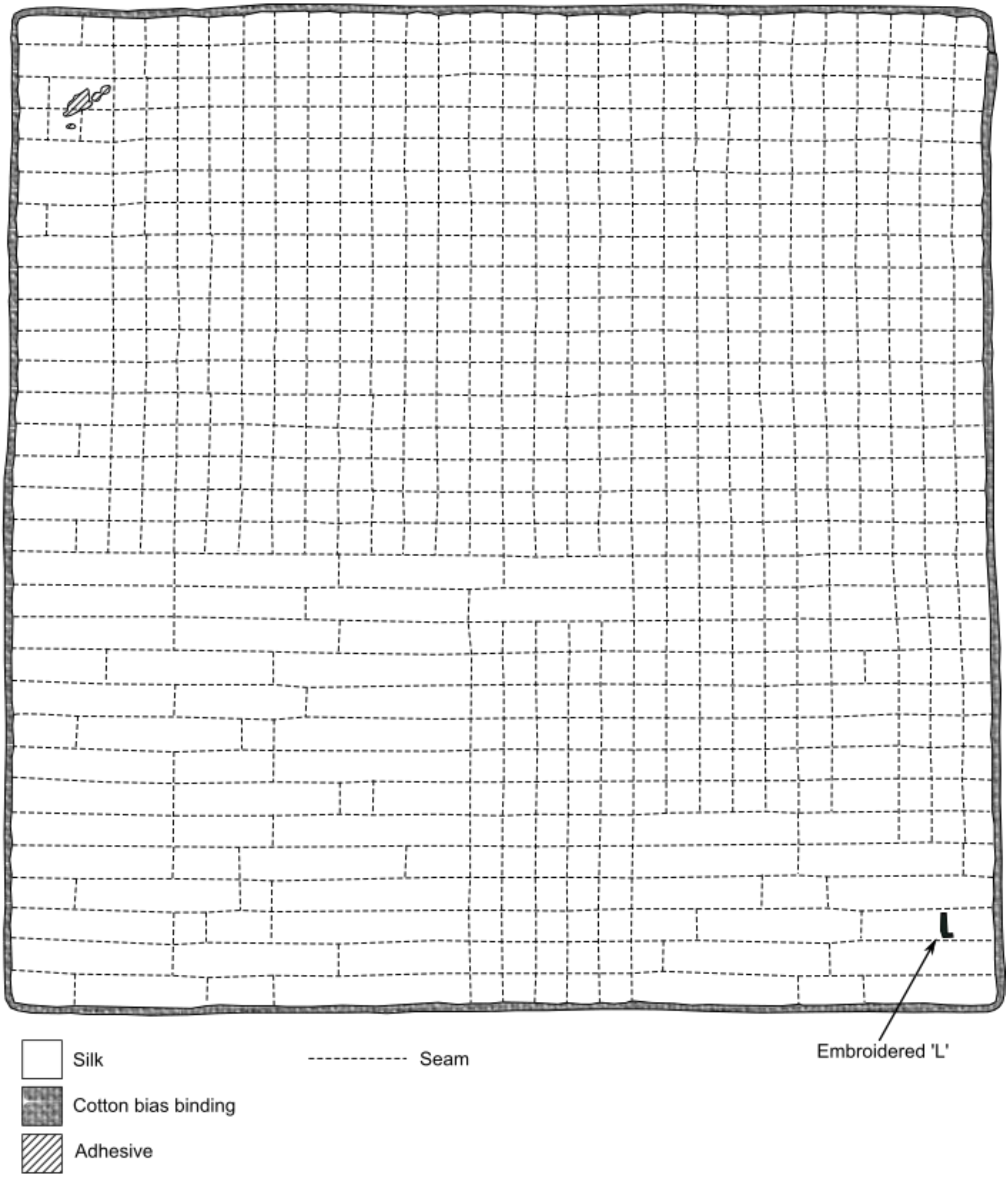


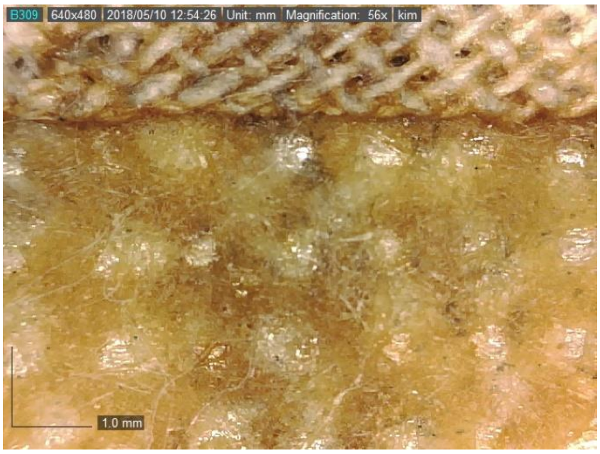
Figure 3 – Overall back construction and soiling

3.3 Condition report

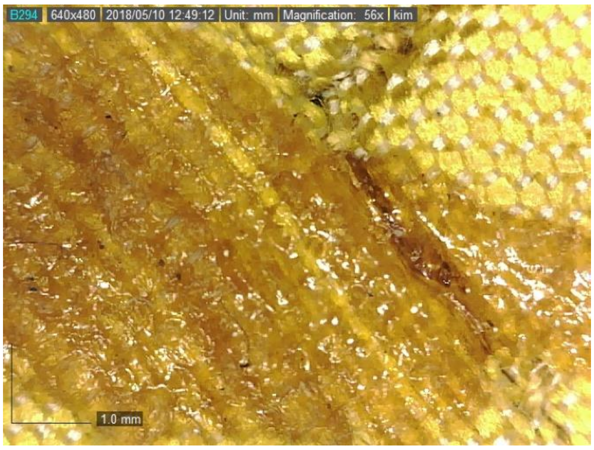
3.3.1 Soiling, staining and discolouration

The adhesive used has severely degraded, losing its adhering properties and becoming stiff and brittle. It has also discoloured a dark yellow orange. Most of the adhesive is on the back (see Figure 3), where it is heavily embedded in the fusible lining (see Figure 4).

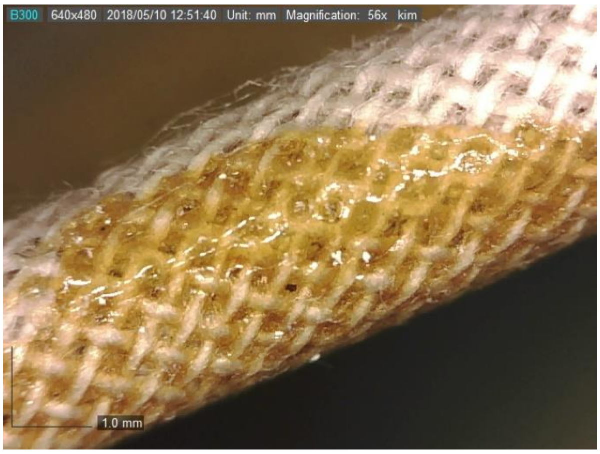
Figure 4 – Adhesive staining under Dino-Lite magnification



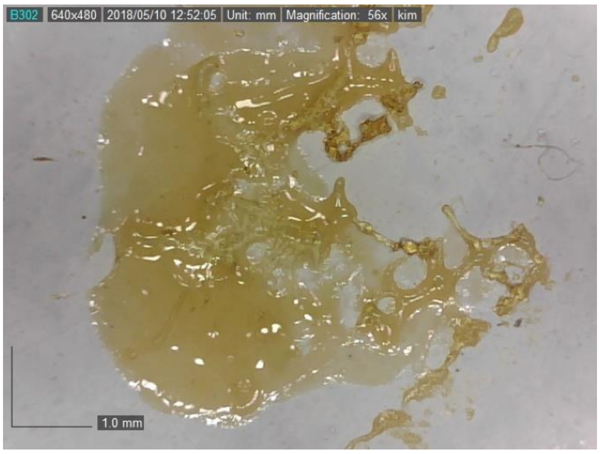
Adhesive on back



Adhesive on front



Adhesive on binding



Adhesive on backing board

There is also a small amount of adhesive on the front at the top left (see Figure 2) which was likely deposited by accident. It is a thicker layer than the adhesive on the back, yellow, transparent and shiny above the surface of the silk (see Figure 4). It is less embedded than the adhesive on the lining as no pressure was placed on this area. There are also small areas of adhesive on the binding, mostly on the back but also some at the sides (see Figure 4). Finally, there is also adhesive residue left on the backing board. This is mostly located where the mosaic was adhered, but there are small areas outside this area. The adhesive is sitting on the surface of the paint and looks similar to the accretion on the front of the silk –

yellow, clear and shiny (see Figure 4). The yellowing and discolouration of the adhesive are both a possible result of chain scission and cross-linking of the adhesive polymer chains. The yellowing could also be a result of chemical changes or elimination of the polymer side groups creating unsaturated chromophoric systems.[74]

The object is under fifty years old and the degradation of the adhesive has been relatively fast. As the mosaic was kept in Lucienne and Robin Day's house,[75] and then at the Whitworth, it is unlikely that environmental conditions were extreme enough to cause this degradation. It is more likely that the adhesive itself was unstable, and the degradation accelerated by pollutants formed by the deterioration of the adhesive itself.[76] This could explain why the discolouration of the adhesive is greater on the back, where any pollutants would have been trapped and accelerated the degradation. If this is the case, then these pollutants may not only continue to further degrade the adhesive, but could also cause deterioration of *Golden Tangram*.

There are areas of different coloured discolouration on the back. These appear to be where the adhesive has fully impregnated the lining and become embedded in the turned over silk edges. There is a possibility that this discolouration was a result of either dye bleed or ink transfer from the paper template. However, research has shown that the paper used was heavy graph paper and examining *Golden Tangram* with transmitted light showed no evidence of inked paper.

3.3.2 Distortion and creasing

There is some distortion which is a result of the hardened adhesive. There is an indented and stiffer area at the centre where the adhesive was applied heavily and most embedded (the area still adhered to the MDF board). The edges of the mosaic were also slightly turned up as the adhesive has failed around the edges and stiffened, creating differential tension in the lining. This tension has been released now that the object has been removed from the backing board.

3.3.3 Physical damage and loss

There is very little physical damage. The natural slubs in the silk are raised and more vulnerable to accidental mechanical damage resulting in some slightly frayed threads. There are also broken threads from needle holes made when the silk was tacked on to the paper

[74] Timár-Balázsy and Eastop, 321-322.
[75] Day.
[76] Tímár-Balázsy and Eastop, 321.

templates. Finally, there are some very small chips in the white paint (<3mm) on the edges of the backing board.

3.4 Conclusion

Golden Tangram and the backing board are both in good overall condition with only very minor physical damage from construction and general wear-and-tear which is not at risk of worsening. The main condition issue is the degradation of the adhesive used to secure the mosaic to the backing board. This has lost its adhering properties, discoloured a dark yellow, and become hard and brittle. Aside from the loss of adherence and the visual disfigurement, there is also a risk that it will continue to degrade and potentially release pollutants that could damage the mosaic in the long term.

Chapter 4: Characterising the Adhesive

4.1 Introduction

There are two main aims in characterising the adhesive used on *Golden Tangram*.

- To inform its likely stability and future degradation pathway, thus determining the extent of removal required.
- To inform possible methods of removal in terms of practical method, the solvent required and also to identify suitable materials for testing these.

Two methods used for this process were chosen following the literature review – FTIR analysis and solubility testing. As mentioned in Chapter 2, neither method guarantees a conclusive result. However, used in conjunction with visual analysis, they may allow for reasonable assumptions to be made about the adhesive type.

4.2 Methodology

As discussed in Chapter 2, successful FTIR analysis relies on having suitable spectra of known materials for comparison. Therefore, the adhesive was examined visually by the naked eye and under magnification to define the degradation of the adhesive, which could indicate what type of adhesive had been used.

FTIR analysis was undertaken on adhesive samples taken from four locations on the back of *Golden Tangram* and the locations noted. Three samples per location were analysed to account for any anomalous spectra which could result from sample contamination. The resulting spectra were compared to those of known modern adhesives and spectra of aged adhesives found in other sources.

Solubility testing was then undertaken and samples taken in the same way as for the FTIR analysis. There was a risk that, as the samples for the solubility and FTIR analyses were taken from different locations, results of the solubility analysis may not apply to other areas of the adhesive. However, the adhesive on the back should react similarly regardless of precise location, and the multiple FTIR samples should indicate any major differences between different locations.

The solubility testing results were plotted on a Tea's chart and compared to those of known adhesives. This supported the FTIR analysis, but also provided information on possible solvents for use in the eventual treatment of *Golden Tangram*.

4.3 Visual examination

The adhesive on *Golden Tangram* was examined by the naked eye and under magnification using a stereomicroscope. Please refer to the condition report in Chapter 3 for full observations.

4.3.1 Methodology

The adhesive is yellow, hard and brittle. As the adhesive is present on the front of *Golden Tangram* and on the backing board, it can reasonably be assumed that originally it was not visibly disfiguring and likely colourless and transparent. Therefore, initial research into adhesive degradation focused on adhesives that yellow and become brittle with age: four types of adhesives were investigated – two modified cellulosic adhesives, and two synthetic adhesives.

4.3.2 Modified cellulosic adhesives

Cellulose ethers and cellulose nitrates are commonly highlighted as being relatively unstable and more susceptible to degradation with both discolouring in the long term.[77] Of the cellulose ethers, the alkoxyalkyl ethers, such as ethylhydroxyethylcellulose and hydroxypropylcellulose, are more prone to discolouration and decreasing in molecular weight with thermal and light degradation.[78] However, the adhesive on *Golden Tangram* is unlikely to be a cellulose ether, as these are less commonly found as commercial adhesives, except for methyl cellulose wallpaper paste. It is also unlikely that *Golden Tangram* was exposed to sufficient light or heat to cause the advanced degradation of the adhesive.

Cellulose nitrates can age by elimination of the nitrate side groups resulting from oxidation and hydrolysis at room temperature. This is catalysed by the nitric acid formed by the nitrogen dioxide with atmospheric oxygen and moisture.[79] They can be more stable if these pollutants are allowed to evaporate.[80] The adhesive on *Golden Tangram* could be cellulose nitrate based – these adhesives are available commercially as modelling and wood glues – Paula Day has advised that Robin Day often used woodworking glues.[81] Also, they are clear and colourless when dry, and degrade at room temperature.

---

[77] Down, 55 and 61.
[78] R. L. Feller and M. Wilt, *Evaluation of Cellulose Ethers for Conservation* (Los Angeles: The Getty Conservation Institute, 1990) 63.
[79] Timár-Balázsy and Eastop, 321.
[80] Horie, 214.
[81] Day.

4.3.3 Synthetic adhesives

Two synthetic adhesives were found to have similar ageing properties to the adhesive of *Golden Tangram* - polyvinyl acetates (PVACs) and polyvinyl acrylates (acrylic adhesives). Both are generally considered to be relatively stable. However, while poly methyl methacrylate (PMMA) is stable to heat, oxygen and UV/light ageing, higher methacrylate polymers, i.e. poly ethyl methacrylate (PEMA) and above, are susceptible to cross-linking with visible light exposure.[82] Different acrylic adhesives have also been found to degrade in different ways – some increasing and some decreasing in flexibility with time – while particular brands of acrylic adhesives have been found to yellow with age.[83] Research by Down also showed that despite relative stability, PVACs were found to yellow twice as quickly as acrylic adhesives and so must also be considered as a possibility.[84] PVACs and acrylic adhesives are also commercially available under several brands, and usually dry to a clear and colourless appearance.

4.3.4 Conclusion of visual analysis

The visual analysis and literature suggest the adhesive on *Golden Tangram* is likely a cellulose nitrate, PVAC or acrylic adhesive as these are known to age in a similar way – prone to yellowing and becoming hard and brittle. They are all also available as commercial adhesives. These findings have been used as a starting point for the analysis of the FTIR spectra.

4.4 FTIR analysis

FTIR can be used to identify the chemical bonds present within organic materials – the test sample is exposed to infrared radiation which causes its chemical bonds to vibrate in multiple ways. Specific frequencies of the infrared have corresponding energies that cause particular bonds to vibrate in particular ways when they absorb that energy. This absorption is measured and plotted as a spectrum for analysis.[85]

---

[82] Ibid., 153.
[83] Down, 84.
[84] Jane L Down et al., "Adhesive Testing at the Canadian Conservation Institute: An Evaluation of Selected Poly(Vinyl Acetate) and Acrylic Adhesives," *Studies in Conservation* 41, no.1 (1996): 38, accessed June 2, 2018, https://www.jstor.org/stable/pdf/1506550.
[85] Michelle R. Derrick, D. S. James, and M. Landry, *Infrared Spectroscopy in Conservation Science* (Los Angeles: Getty Conservation Institute, 1999), 14.

4.4.1 Methodology

Samples of the adhesive were taken from the back of *Golden Tangram* in four areas (see Appendix 3). Three samples (<0.5mm) were taken from each area to account for any contaminants that might be present. The samples were analysed using a Perkin Elmer Spectrum One FTIR Spectrometer (Spectrum software version 5.0.1) fitted with a Universal attenuated total reflection (ATR) accessory. 32 scans were taken per sample with a resolution of 4.00cm^{-1}. The resulting spectra were then compared with a variety of spectra from known conservation grade adhesives and commercially available adhesives, focusing on cellulose nitrates, PVACs and acrylic adhesives. All spectra were baseline corrected and smoothed using KnowItAll® Informatics System, Academic Edition ©2018.

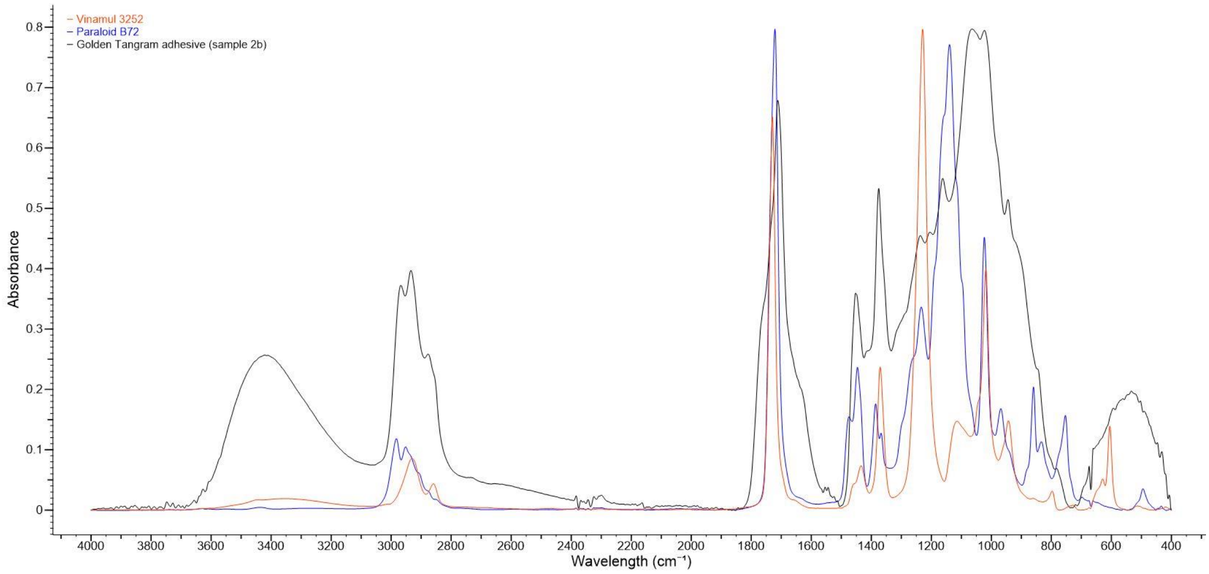
4.4.2 Results and discussion

The resulting spectra, while showing different levels of attenuation, were consistent in shape except for varying heights of peaks around 1650cm^{-1} and 840cm^{-1}. They did not directly match any spectra of known samples, but this was to be expected given the degradation of the adhesive.[86]

Initial analysis suggested some similarities in shape to the spectra of PVAC and acrylic adhesives, as seen in the below image comparing the adhesive spectra to that of Vinamul 3252, a conservation grade PVAC, and Paraloid B72, a conservation grade acrylic copolymer adhesive. However, the differences could not be explained by any evidence found in previous research on the ageing of these adhesives. Neither reference spectra displayed the broad double peak around 1060-1020cm^{-1}, while the large peaks at 1230cm^{-1} and 1140cm^{-1} (seen on PVAC and Paraloid respectively) were not visible on the sample spectra. Likewise, the carbonyl peak (around 1720-1710cm^{-1}) was also at a different wavelength and significantly broader. While this could be attributed to ageing, past research has shown that while this peak may decrease in attenuation with age, its position does not.[87]

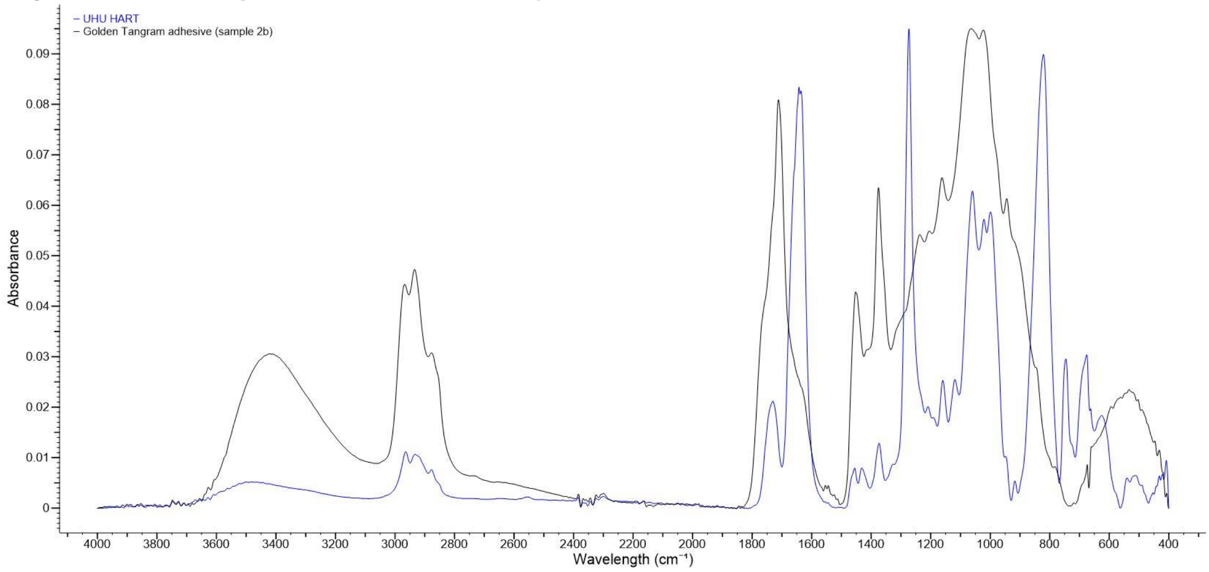
[86] Horie, 58.
[87] Lomax and Fisher, 184.

Figure 5 – FTIR spectra of *Golden Tangram* adhesive, PVAC and Paraloid B72



The sample spectra also did not appear to relate to those of known cellulose nitrate adhesives.

Figure 6 – FTIR spectra of *Golden Tangram* adhesive and UHU hart



However, research has shown that cellulose nitrate adhesives undergo a denitrification process with age that does alter their FTIR spectra. This can be seen in the decrease in absorption of the nitrogen related peaks around 1650cm^{-1}, 1280cm^{-1} and 840cm^{-1}, which correspond to asymmetrical stretching of the nitrate group, symmetrical stretching of the nitrate group and stretching of the N-O bond respectively.[88] This denitrification can also result in the formation of a carbonyl group which is represented on the FTIR spectra as a

[88] Berthumeyrie et al., 140.

peak around 1720cm^{-1}.[89] Also a common additive used in cellulose nitrate, camphor, could affect the FTIR spectra – on its own it has demonstrated absorption peaks at 1738cm^{-1}, 1044cm^{-1} and 1021cm^{-1}.[90]

4.4.3 Additional analysis

A diphenylamine spot test was performed to detect the presence of cellulose nitrate. This was done following the method recommended by the Canadian Conservation Institute.[91] The diphenylamine solution was tested on known cellulose nitrate adhesives with positive results before use on the sample adhesive. The sample adhesive gave a negative result, turning a black/brown colour, rather than violet/indigo which would indicate a positive result. However, this does not necessarily mean there was absolutely no cellulose nitrate present. It has been shown that very degraded samples of cellulose nitrate material can turn this dark colour, which conceals any positive result indicated by the lighter violet/indigo colour.[92] Also the denitrification degradation process could have progressed too far to produce a positive result.

4.5 Solubility testing

4.5.1 Methodology

Samples of a similar size to those taken for FTIR analysis were taken from one area of the back of the object (see diagram). Solvent was dropped in successive single drops on to the samples using a glass pipette while under observation under a polarised light microscope. The samples were observed to see if the solvent caused the adhesive to solubilise, or if there were any changes in the size of the sample that may indicate swelling and partial solubility. Once the solvent had mostly evaporated, mechanical pressure was put on the samples using a dissection needle to see if the texture had changed, as a gel-like texture would indicate partial solubility. The results of these tests were plotted on to a Tea's diagram to identify areas of solubility, insolubility and partial solubility, and compared with known solubility parameters of various adhesives.

---

89 Shashoua, Bradley and Daniels, 117.
90 Noake, Lau and Nel, 5.
91 R. Scott Williams, "The Diphenylamine Spot Test for Cellulose Nitrate in Museum Objects - Canadian Conservation Institute (CCI) Notes 17/2 - Canada.Ca," 1994, accessed June 11, 2018, https://www.canada.ca/en/conservation-institute/services/conservation-preservation-publications/canadian-conservation-institute-notes/diphenylamine-test-cellulose-nitrate.html.
92 R. Scott Williams, "Stock Solution for Preparation of Diphenylamine Reagent for Cellulose Nitrate Identification--Conservation DistList," 2008, accessed June 11, 2018, http://cool.conservation-us.org/byform/mailing-lists/cdl/2008/1344.html.

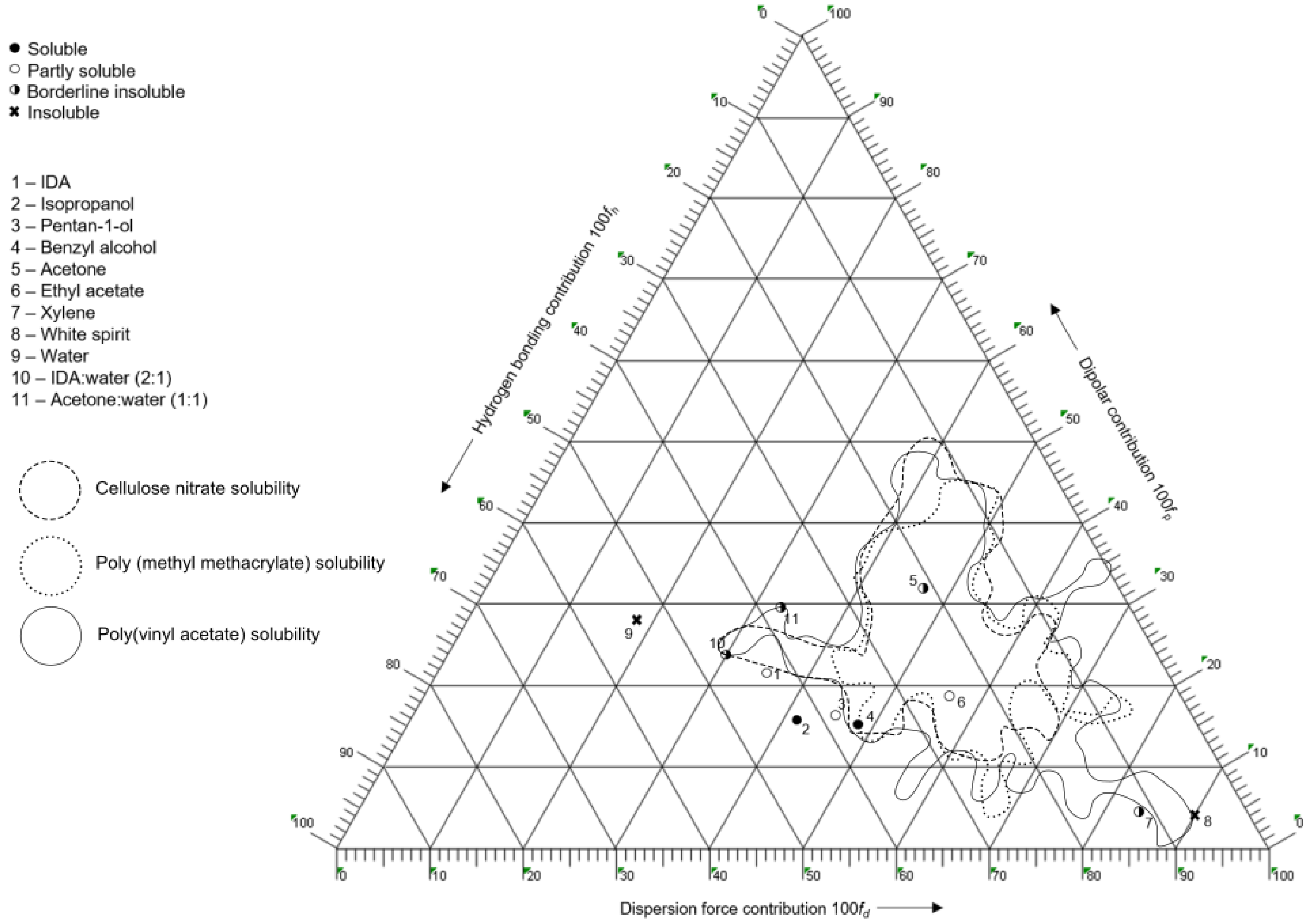
4.5.2 Results and discussion

Table 2 – *Golden Tangram a*dhesive solubility results

Solvent	Result
IDA	Partly soluble. Decreased in size and then swelled. Gel like texture formed.
Isopropanol	Very quick solubilisation. Gel like texture formed while solubilising.
Pentan-1-ol	Partly soluble. No size change but gel like texture formed.
Benzyl alcohol	Soluble but slower than Isopropanol. Remained crystalline throughout.
Acetone	Borderline insoluble. Slight decrease in size but no change in texture.
Ethyl Acetate	Partly soluble. Immediate swelling then decreased in size. Sticky gel like texture formed.
Xylene	Borderline insoluble. Slight swelling with no change in texture.
White Spirit	Insoluble - no reaction
Water	Insoluble - no reaction
IDA: water (2:1)	Borderline insoluble. No size change but became slightly sticky.
Acetone: water (1:1)	Borderline insoluble. No size change but became slightly sticky.

The solubility test results showed that the sample adhesive was soluble in isopropanol and benzyl alcohol. It was partially soluble in other alcohols, acetone, ethyl acetate and xylene, and insoluble in white spirit. These results were not exactly compatible with any of the adhesives highlighted in the previous characterisation results.

Figure 7 – Tea's chart for *Golden Tangram* adhesive



All solubility parameters taken from Horie, except for benzyl alcohol (taken from https://researcher.watson.ibm.com/researcher/files/us-flinte/SPM.pdf). Chart adapted from https://es.wikipedia.org/wiki/Diagrama_ternario#/media/File:Ternary_plot_1.png.

PVAC, acrylics and cellulose nitrate all have a much larger area of solubility than the *Golden Tangram* adhesive (see Figure 7). As per Chapter 2, polymers can decrease in solubility with age or degradation, so it is reasonable to assume that this is why the *Golden Tangram* adhesive has such a small area of solubility. For example, all of the reference adhesives were soluble in acetone and ethyl acetate, but the *Golden Tangram* adhesive was not.

The adhesive was also soluble in more polar substances than the reference adhesives. As per Chapter 2, polymers become more polar with age. Following the 'like dissolves like' principle, it stands to reason that more polar solvents would be more effective on the degraded adhesive than the reference adhesives which are unaged. For example, as the area of solubility is in a more polar region, pentan-1-ol, which does not solubilise cellulose nitrate and acrylics, partly solubilised the *Golden Tangram* adhesive.

Unfortunately, as the adhesive is so degraded no meaningful results can be drawn from the solubility tests. The area of solubility is very small, and not comparable to any available reference adhesive (including adhesives not highlighted in previous results). However, given that adhesives are known to become less soluble and more polar with age, the results do not directly contradict any conclusions drawn from visual examination or FTIR.

4.6 Discussion

As expected, positive identification of the adhesive was not possible. It would require the ageing of several commercial adhesives for exact comparison, and, even then, the spectra may differ due to unknown additives or changes in the manufacturer's content.

From the FTIR results, the adhesive appears to be cellulose nitrate-based. Studies on its ageing show the FTIR spectra can alter to something like that of the adhesive from *Golden Tangram*. This conclusion is supported by the known degradation pathways and appearance of cellulose nitrate adhesives, which match those of the *Golden Tangram* adhesive. However, the diphenylamine spot test was negative, although this too may not be 100% reliable given the degradation of the adhesive. Solubility tests neither confirmed nor negated this conclusion. It is possible that degradation and ageing of a cellulose nitrate adhesive could alter its solubility parameters to those of the *Golden Tangram* adhesive.

4.7 Conclusion

The results of the adhesive characterisation were not conclusive, but the adhesive could well be cellulose nitrate-based. Such adhesives degrade readily at room temperature. It will likely continue to deteriorate and release degradation products that can form pollutants that could cause degradation of *Golden Tangram.* Even if the adhesive is not cellulose nitrate-based, the quick deterioration of the adhesive, which is on the back and has been protected from UV, light and atmospheric pollutants, suggests there are by-products produced by the adhesive that are catalysing its degradation. These could be harmful to the object. However, the adhesive has so far degraded with minimal deterioration of the textiles, and, if the adhesive is cellulose nitrate-based, it is possible the majority of the nitrates have already been lost, resulting in a negative diphenylamine spot test.

Following the results of the characterisation, testing of adhesive removal methods was undertaken using a cellulose nitrate-based adhesive. These have been shown to have similar physical properties to the adhesive on *Golden Tangram* and should pose similar practical issues in terms of removal. An additional benefit is that the nitrogen associated bands are easily identifiable with FTIR, and so this method could be used to analyse results.

Chapter 5: Treating the Adhesive

5.1 Introduction

Using the results of Chapter 4, this chapter focuses on finding a potential method to remove as much adhesive from *Golden Tangram* as possible. The solubility testing confirmed an organic solvent will be necessary to remove the degraded adhesive. Exactly how this solvent could be applied will be explored in this chapter.

The main issue in treatment will be removing the solubilised adhesive while also controlling its movement so it does not penetrate further into the object, or spread laterally, causing wider stains, ringing or other visual disfigurement. Other risks include damage to the textile fibres, dye bleed, and unwanted reactions with the unknown layers, i.e. the backing of the silk pieces and the fusible lining. In addition, the practicality, health and safety precautions and resources required for the treatment need to be taken into account.

5.2 Past adhesive removal treatments

Based on findings from Chapter 2, the methods considered for use on *Golden Tangram* will be immersion, dropping solvent with a vacuum suction table, and poulticing, if necessary in conjunction with mechanical action.

5.2.1 Immersion

Soiled textiles can be immersed in organic solvents that solubilise the soiling so it can be removed. As organic solvents are volatile and usually toxic, it is recommended that solvent immersion treatments are carried out in a fume cupboard so the solvent vapours are contained and removed safely.[93] It is important to avoid soil re-deposition - only clean solvent should be used which should be replaced as it is ‘exhausted’, and the textile given a final rinse in clean solvent.[94]

In terms of removing the adhesive, this method poses the least risk of unwanted movement of the adhesive residue and therefore ringing and tide marks, as the adhesive should be fully solubilised and removed with rinsing. Immersion, however, poses the greatest risk in terms of drying out the fibres, dye bleed and reactions with the unknown layers, as the whole object will be in prolonged contact with a relatively large quantity of the solvent.

---

[93] Timár-Balázsy and Eastop, 182.
[94] Ibid., 182-183.

While the cleaning process is relatively quick and simple compared to other methods, it can take a long time for the solvent to fully evaporate – up to a few days, depending on the evaporation rate.[95] Of the methods selected, immersion requires the most solvent, increasing the cost and potential health and safety hazards. However, as *Golden Tangram* is relatively small, the treatment could be carried out in a fume cupboard with minimal risk.

5.2.2 Vacuum suction table

Vacuum suction tables can be used to control localised cleaning of a textile. The textile is laid on the table surface and solvent dropped or brushed on to it. The suction of the table draws the solvent and the dissolved soiling through the textile. The effectiveness of this can be increased with an absorbent layer, i.e. blotting paper, between the textile and the table, as the capillary action promotes the movement of the dissolved soil.[96]

This method can reduce ringing from lateral movement of the solubilised adhesive, as the suction draws this down and away from the textile.[97] The solvent can also be applied from outside the stain, working inwards to reduce the outward lateral movement – this is known as 'feathering out' and requires an absorbent layer between the textile and table.[98] The likelihood of dye bleed or unwanted reactions with the unknown layers is less than with immersion as the materials are not in contact with the solvent for a long time. However, this short contact time could potentially reduce the amount of adhesive that is solubilised. There should also be less chance of the fibres drying out.

This method is simple and quick to carry out. Using an extraction hood should draw all solvent vapours away from the conservator. This method would use more solvent than a poultice treatment but less than immersion.

5.2.3 Poultices

In conservation, a poultice refers to a soft medium that is mixed with an active agent. When the poultice is applied to the textile, the active agent, or solvent in this case, diffuses into the textile to form an equilibrium where the concentration of solvent is equal in the poultice and the textile. The solvent is then able to solubilise the soiling in the textile. As the solvent

95 Ibid., 183.
96 Ibid., 183.
97 Karen Thompson, "An Investigation into the Use of Poultices for Removing Adhesives from Textiles?" (PGDip report, Textile Conservation Centre, Courtauld Institute of Art, 1993), 27
98 Timár-Balázsy and Eastop, 183.

evaporates from the poultice, solvent, along with the solubilised soiling, is drawn back into the poultice to rebalance the equilibrium, thus cleaning the textile.[99] The method relies on continuous movement of the solvent through the textile and poultice, and therefore good contact between the two is essential.[100] The poultice should be left in place on the textile for the solvent to fully evaporate – if it is removed before it is dry, then not all the solubilised soiling will have been drawn into the poultice and it will remain on the textile.[101] Methods of poulticing can be tailored as needed. If there is risk of difficult to remove poultice residue on the textile, a barrier layer can be used between the two, although this may reduce the capillary action. The poultice can also be covered, closing the poultice system. This allows for a greater concentration of solvent to diffuse into the textile, with more time to solubilise the soiling.[102] Depending on the method and the solvent, poultices can also be used to merely soften or swell soiling rather than solubilise it if desired.[103]

There is more risk of adhesive movement laterally through the textile and ringing than an immersion treatment, but various methods of poultice application can control this movement. Thompson recommended using a dry halo poultice whereby the poultice mixed with the active agent is placed on the soiled area, and then surrounded with a halo of dry poultice medium. The aim of this is to reduce lateral movement of the solubilised adhesive as any solvent moving outside of the soiled area should be drawn up by the dry halo.[104] Developing this method, Sam recommended a wet halo poultice, which is the reverse of the dry halo – the soiled area is covered in dry poultice medium and surrounded with poultice containing the active agent. In order to gain equilibrium, the internal dry sepiolite draws the solvent from the wet poultice halo towards and through the soiled area, reducing outward movement and maximising capillary action in the soiled area.[105] Finally, Sam developed a double poultice method, using separate poultices to supply and absorb the active agent. They are applied in succession so the active agent and any solubilised soiling are quickly removed so that lateral movement is limited.[106]

---

[99] Louise Wing-ah Sam, "An Investigation into the Modification of Methods to Improve the Performance of Poultice Cleaning on Textiles," (MA dissertation, The Textile Conservation Centre, University of Southampton, 2003), 6-7.
[100] Thompson, 7.
[101] Ibid., 17.
[102] Ibid., 17.
[103] Ibid., 10.
[104] Ibid., 62.
[105] Sam, 63.
[106] Sam, 59.

Even if the adhesive can be solubilised fully, it is unlikely a poultice treatment will remove more adhesive than an immersion treatment as it relies on achieving the best capillary action. However, this method poses the least risk of adverse effects on the fibres and unknown layers and dye bleed as minimal solvent is used.

A poultice treatment is the most complicated to carry out – it requires constant monitoring and the most preparation before the procedure. However, it also requires the least amount of solvent as the poultice allows for only a small amount of solvent to be held in close contact, safely and for a longer period of time than the solvent evaporation rate would usually allow.[107]

5.3 Material choice and preliminary testing

Results from Chapter 4 together with the research into past adhesive removal methods undertaken in Chapter 2 were considered in choosing the adhesive and poultice material for testing. Further preliminary tests using basic mock-ups were then undertaken to determine which solvents were required, whether and which barrier layers were needed for poultice methods, and to identify suitable parameters for testing, i.e. poultice depth, solvent quantity etc., for the main adhesive removal trials.

5.3.1 Test adhesive

As explained in Chapter 4, a cellulose nitrate adhesive was chosen for testing. UHU hart was chosen as it is known to be cellulose-nitrate based,[108] is commercially available, and on application looks to have similar properties to the adhesive on *Golden Tangram*. Ageing the adhesive was considered, but was ultimately not possible in the time available. However, ageing the adhesive would have aged the mock-ups it was applied to, which would be unsuitable as *Golden Tangram* is in good condition. Using an unaged adhesive also has the benefit of providing a ‘worst-case scenario’. In terms of achieving a good visual result, the movement of the adhesive is the biggest concern, and this would be hardest to control with a new adhesive that is still easily solubilised.

5.3.2 Poultice material

There are several different options for poultice absorbents, each with different properties. The case studies included in the literature review were considered together with Thompson’s dissertation exploring poulticing in textile conservation to narrow these down.

[107] Ibid., 1.
[108] Confirmed with diphenylamine spot test.

Sepiolite has been used with success in the past by Heuman on a cellulose nitrate adhesive. It is a naturally occurring hydrous magnesium silicate clay with a high surface area and porosity, giving it a very good absorption capacity for liquids.[109] Thompson also found sepiolite to be a very effective poultice absorbent, including when used to swell and remove Shellac.[110] However, it does leave residue. This can be removed with mechanical action and vacuum suction, or a barrier layer can be used to isolate the sepiolite, although this reduces the capillary action.

In addition, sepiolite poultices are quick and easy to prepare and handle during the cleaning process. It was therefore decided to use them for all poultices in the main trials.

5.3.3 Test solvents

A solvent that totally solubilises the test adhesive was required for both the immersion and vacuum suction table trials so that the adhesive was able to move all the way through the mock-ups. However, the solvent required for the poultice method depends on the desired effect, i.e. to soften or solubilise the adhesive. Both methods have been used in the past - Carlson used a poultice to apply a solvent that softened the adhesive so it could be removed mechanically,[111] whereas Heuman and Garland chose a solvent that would solubilise the adhesive so it could be drawn up into the poultice.[112] These two methods could both be used to effect on *Golden Tangram.* The thicker, less embedded adhesive on the front could be softened and reduced mechanically, whereas the more embedded adhesive on the back could be drawn up after being solubilised.

Solubility tests were carried out on the UHU hart using the same method as during the adhesive characterisation in Chapter 4. Ethyl acetate was found to solubilise the test adhesive and a mixture of 5:1 IDA:acetone softened it without it solubilising. These solvents were therefore used in the preliminary trials.

[109] "Sepiolite", IMA Europe, accessed July 11, 2018, https://www.ima-europe.eu/about-industrial-minerals/industrial-minerals-ima-europe/sepiolite.
[110] Thompson, 57.
[111] Carlson, 4.
[112] Heuman and Garland, 30.

5.3.4 Preliminary tests

Preliminary tests were undertaken and the parameters below chosen for the main testing following the results. For full details of preliminary tests see Appendix 4.

1) Barrier layers: A barrier layer is required to prevent sepiolite residue being left on the object. Tyvek® worked most effectively for a poultice to soften the adhesive to allow mechanical reduction, and cotton lawn for a poultice to solubilise the adhesive and draw it up with capillary action.

2) Poultice depth: A depth of 10mm proved effective in preliminary trials, allowing enough solvent contact time and weight for good physical contact.

3) Solvent quantity: A ratio of 2:5 sepiolite:solvent made a poultice that was suitably malleable and heavy enough to promote good physical contact.

5.3.5 Analysis methods

The preliminary trials showed that visual analysis of the results was possible both by naked eye and with magnification. One can easily distinguish the shiny adhesive from the clean fibres.

Further observations were also made, i.e. the handle of the materials after treatment, and the stiffness of the barrier layer - the more adhesive that was drawn away from the mock-up, the softer and more flexible the mock-up was and the stiffer the adhesive impregnated barrier layer.

FTIR analysis was also used. As noted in Chapter 4, the nitrogen-related peaks were clear in the test adhesive spectrum. A reduction in these peaks should indicate a reduction in the amount of adhesive. There were not enough test replicates for quantitative analysis of the FTIR results. However, they supported the results of the visual analysis.

5.4 Main testing

As the adhesives on the front and back of *Golden Tangram* are different in terms of their physical properties and also on different textiles, they pose different issues for treatment – a method used on the back would not necessarily be suitable for the front. It was therefore decided to focus testing on methods to remove the adhesive locally on each side of *Golden Tangram* separately, as well as together as an overall treatment.

5.4.1 Materials and preparation

Mock-ups were prepared based on information on *Golden Tangram* as presented in the object record in Chapter 3. They were made from a combination of 10mm high plain and shot silk strips of different lengths, backed with a fusible Vlieseline® F220 lining, each folded around paper templates and tacked in place. These were then whip stitched together with cotton thread and the tacking removed. They were ironed to hold the folds in place and fusible Vlieseline® F220 lining ironed on to the back. Finally, they were stitched around the edge to hold the lining in place in case it became unadhered during the trials (see Figures 8 and 9).

Figure 8 – Cross-section construction of mock-ups

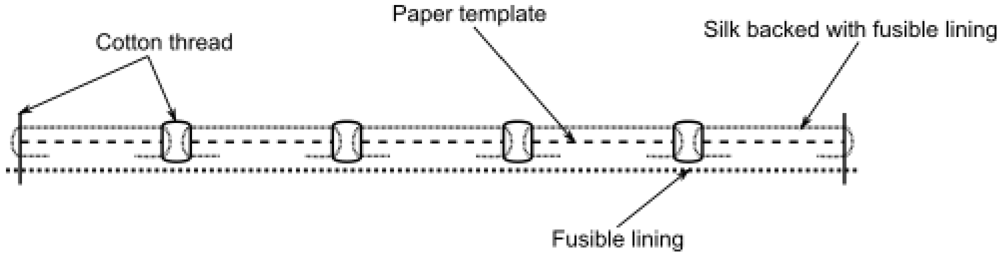
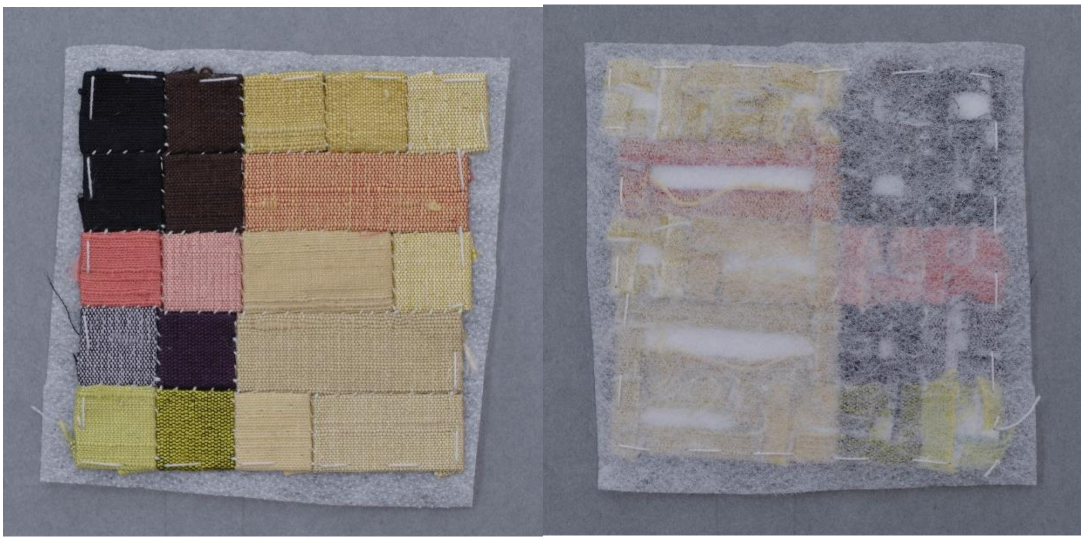


Figure 9 – Completed mock-up



Front *Back*

To replicate the adhesive on *Golden Tangram,* the adhesive was applied to the mock-ups in different ways on the front and the back. A small, thick area of adhesive was applied on the front, while adhesive applied to the back was more spread out and embedded into the mock-up. FTIR spectra and photographs were taken in order to accurately analyse and compare the results of the trials. Reference FTIR spectra of the mock-ups without adhesive were taken, as were three spectra readings of each individual mock-up once they were coated with adhesive. A record was taken of the areas of the mock-ups that underwent FTIR analysis so the same areas could be examined after treatment. These areas were also photographed under magnification with a stereomicroscope, and, finally, overall photographs of all the mock-ups before treatment were taken.

5.5 Trials for adhesive on the back

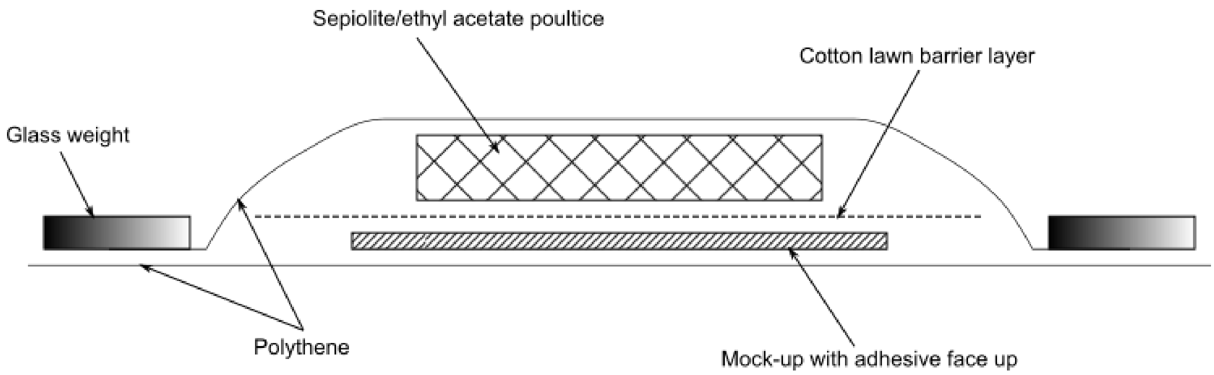
5.5.1 Method

Table 3 – Trial set 1

TRIAL	ADHESIVE LOCATION	METHOD
1a	Back	Single poultice
1b	Back	Double poultice
1c	Back	Dry halo poultice
1d	Back	Wet halo poultice

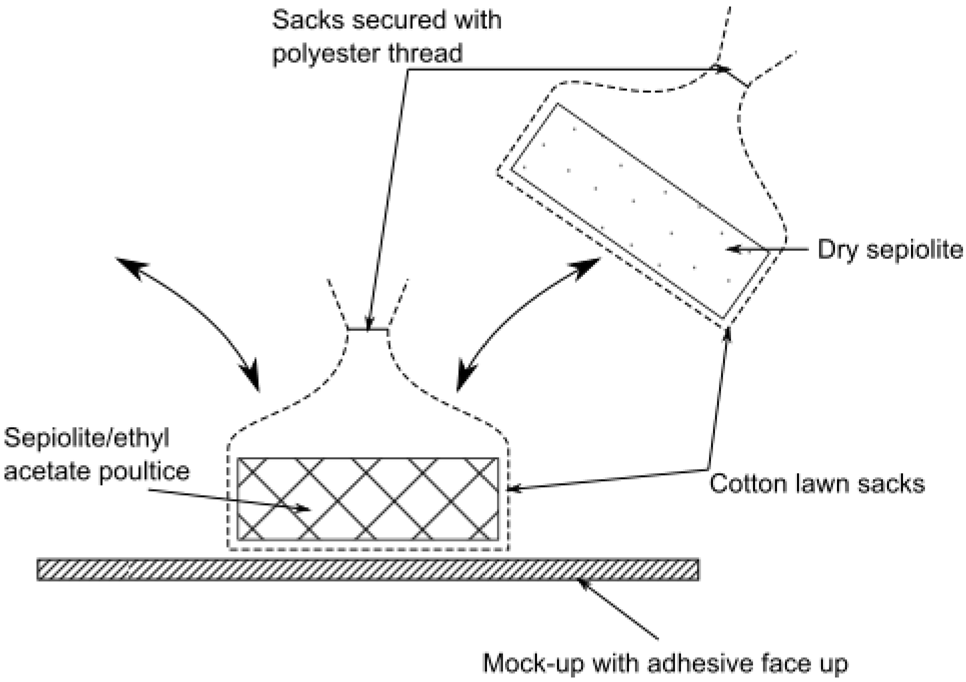
As per Table 3, four methods were trialled to attempt to maximise the capillary action of the poultice and minimise the lateral and downward movement of the solubilised adhesive.

Figure 10 – Single poultice method



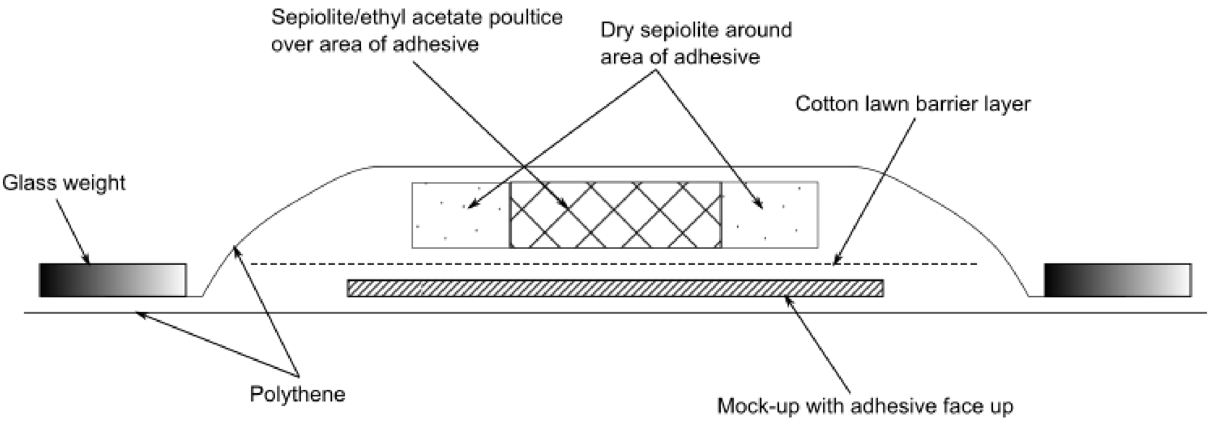
Method 1a used a single poultice with a cotton lawn barrier layer (see Figure 10). The poultice was made to a size that covered the entire area which was coated in adhesive. It was applied on top of the barrier layer, pressed down with gentle finger pressure to ensure full contact, and left covered with polythene for one hour. The poultice was then uncovered and left to dry in situ in a fume cupboard.

Figure 11 – Double poultice method



Method 1b follows the double poultice method. Two poultices sacks were made with cotton lawn – one containing only dry sepiolite, and one with a 2:5 sepiolite:ethyl acetate mixture (see Figure 11). The wet poultice was applied for 15 seconds as a solvent carrier, followed by the dry for 30 seconds as a solvent absorber. This was repeated for an hour.

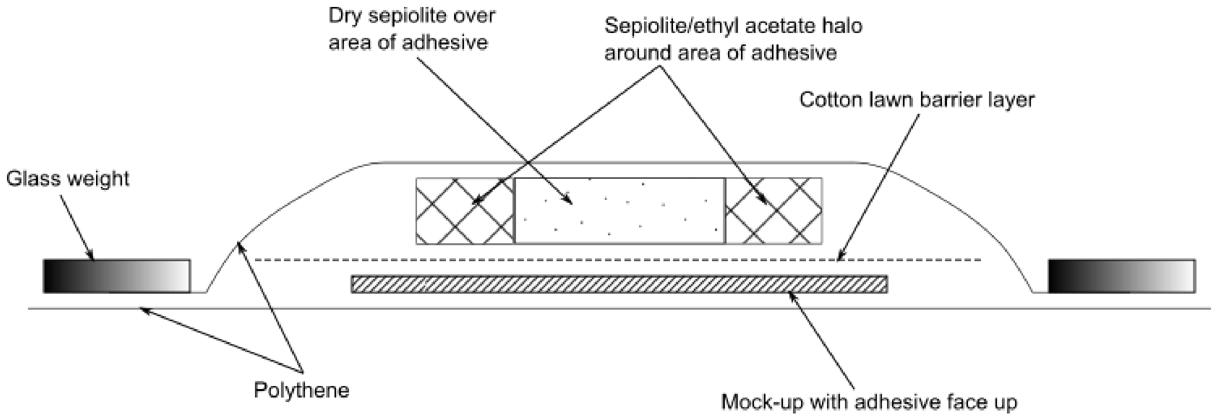
Figure 12 – Dry halo method



Method 1c follows the dry halo method. The poultice was applied as per method 1a, and then the wet poultice was surrounded immediately by a halo of dry sepiolite (see Figure 12).

The poultice was applied on a cotton lawn barrier then covered for an hour and left to dry as per 1a.

Figure 13 – Wet halo method

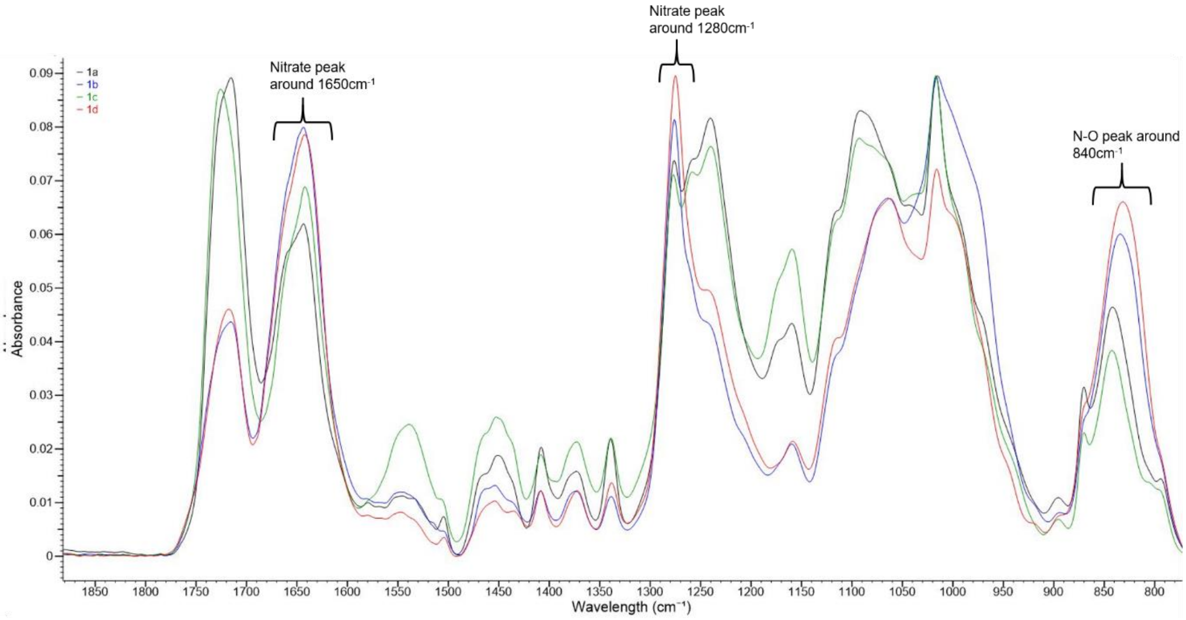


Method 1d follows the wet halo method. The central sepiolite covering the adhesive area was dry and this was surrounded by a wet 2:5 sepiolite:ethyl acetate halo (see Figure 13). The poultice was applied on a cotton lawn barrier then covered for an hour and left to dry as per 1a.

5.5.2 Results

The best visible results were achieved by methods 1a and 1c. These were supported by the FTIR results that showed the nitrogen-related peaks had decreased more than for methods 1b and 1d (see Figure 14). The cotton lawn also effectively prevented any residue from being deposited. 1a and 1c both had a much softer hand-feel on the back.

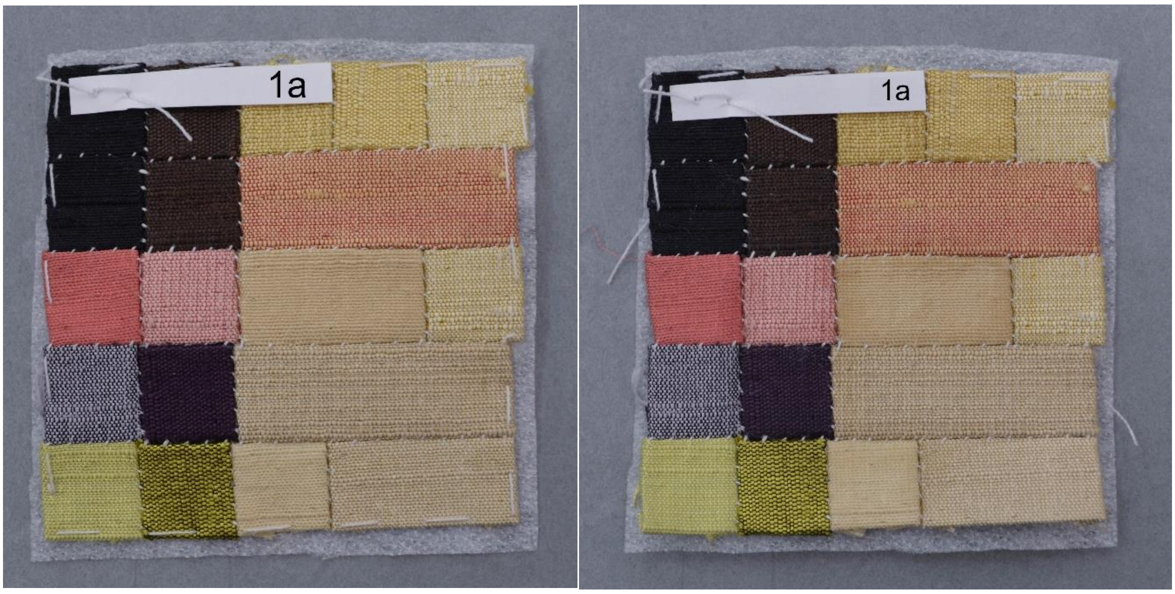
Figure 14 – FTIR results of trial set 1



1b was only minimally successful. This was likely as the solvent needed longer contact time with the adhesive to be effective. The lining was still heavily embedded with adhesive which was almost impossible to remove without damaging the mock-up. 1d was only successful near the area of the wet halo. The dry sepiolite lacked weight and there was not good enough contact for effective capillary action.

However, while 1a and 1c were successful in drawing out the embedded adhesive, both methods resulted in the movement of the adhesive to the front of the mock-ups. The adhesive on the back was very embedded, going all the way through to the silk that was folded over the back of the paper templates. This adhesive solubilised and moved via the turned edges through to the silk on the front. This was visible as ringing on the edges of the silk pieces (see Figure 15). The dry halo was not able to prevent this as the movement occurred in each individual silk piece and not just throughout the area as a whole.

Figure 15 – Trial 1a before and after treatment

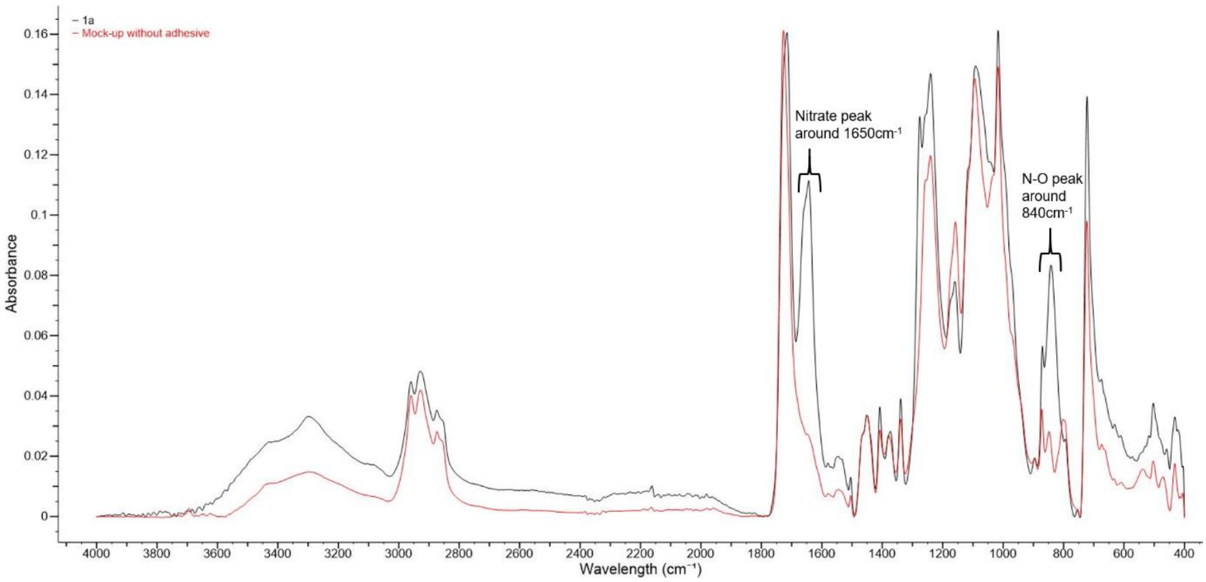


Before Treatment *After Treatment*

5.5.3 Discussion

Method 1a was deemed to be the simplest and most successful method. However, when the FTIR spectra were compared to the original mock-up pre-adhesive coating, it was clear that the nitrogen related peaks, while decreased, were still very much present, suggesting that the adhesive had been reduced but remained in the mock-up (see Figure 16). There was also a larger issue of controlling the solubilised adhesive so that it does not move to the front of the silk pieces. This would not be an acceptable result due to the visual disfigurement of the ringing. The method would need to be adapted or followed with further treatment for a better visual result.

Figure 16 – FTIR results of 1a vs mock-up back without adhesive



5.6 Trials for adhesive on the front

Table 4 – Trial set 2

TRIAL	ADHESIVE LOCATION	METHOD
2a	Front	Softening and mechanical removal followed by single poultice
2b	Front	Softening and mechanical removal followed by dry halo poultice

As per Table 4, two trials were carried out to attempt to remove the adhesive on the front. As this adhesive is thicker, it would be softened with a first poultice treatment and reduced with mechanical action. Lessening the amount of adhesive prior to using a poultice to solubilise the embedded adhesive should lessen the amount of lateral adhesive movement and ringing. The methods used to solubilise the adhesive are the most successful ones from the trials for the adhesive on the back – single poultice and dry halo poultice.

5.6.1 Method

A 2:5 sepiolite:IDA/acetone mix (5:1) poultice was placed on a Tyvek® barrier layer over the area of adhesive on the mock-up in order to soften it. It was then covered with polythene and left for one hour. At 30 minutes, 45 minutes and one hour, the poultice was temporarily removed and the adhesive reduced with a metal spatula. This had to be done quickly as the adhesive re-hardens quite quickly once the poultice is removed. In the initial trials, it was found that some adhesive would stick to the barrier layer and, to avoid replacing this residue back on the object after mechanical removal, the Tyvek® barrier was replaced with a new one after each mechanical removal. After one hour, the poultice was removed entirely so the mock-up could dry.

Following this, trials were carried out to remove the remaining embedded adhesive. Trials 2a and 2b were carried out as per previous trials 1a and 1c respectively. Prior to applying the poultices, the areas of adhesive were marked on the cotton lawn barrier layer in pencil and the poultices moulded to fit these areas only.

5.6.2 Results

The mechanical reduction of the adhesive was successful, removing a lot of adhesive without visibly damaging the silk. However, the area of embedded adhesive remained indented and darker than the surrounding clean silk.

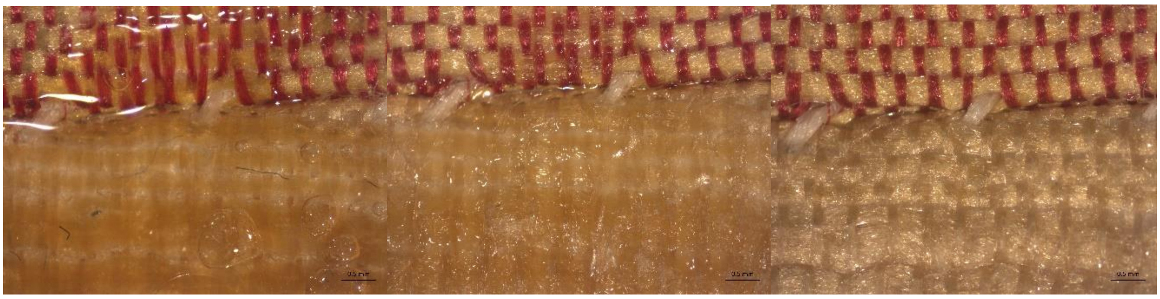
Both methods reduced the amount of adhesive but allowed it to move laterally through the mock-up, resulting in a larger area of darkened silk (see Figure 17). Again, it is likely that the dry halo was not effective due to lack of contact and a reduction in capillary action caused by the presence of a barrier layer.

Figure 17 – Trial set 2 before and after treatment

2a before *2a After* *2b Before* *2b After*

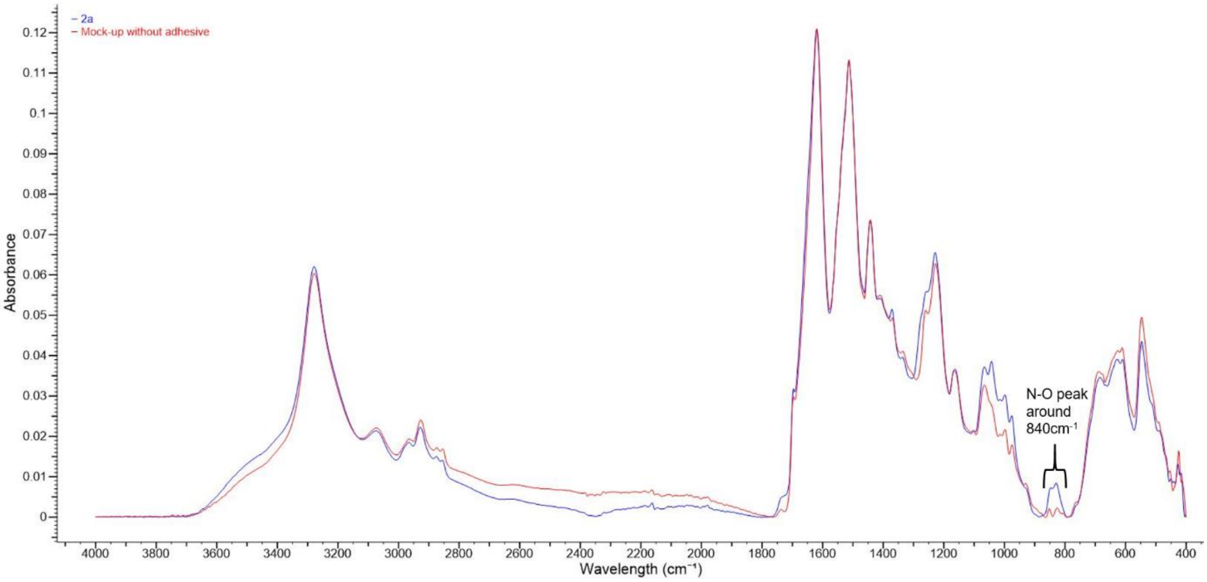
This lateral movement was a significant issue on the front due to the visual disfigurement. That said, very little adhesive remained in the silk. Other than the darkened colour, the adhesive was otherwise not visible under magnification (see Figure 18), and the FTIR spectrum looked almost exactly like that of mock-up before it was coated with adhesive, with the exception of a very small N-O peak (see Figure 19).

Figure 18 – Trial 2a under magnification



Before Treatment *After Mechanical Reduction* *After Treatment*

Figure 19 – FTIR results of 2a vs mock-up front without adhesive



5.6.3 Discussion and further trials

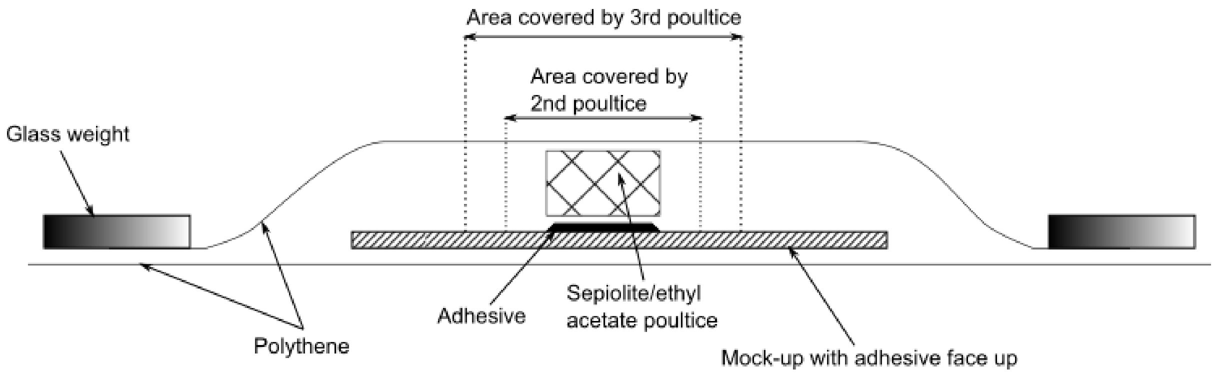
Given the lateral spreading of the remaining adhesive, the poultice methods trialled for removing the embedded adhesive on the front side of *Golden Tangram* were not ideal. Consequently, two further trials were attempted to amend this method. The aim of the trials was to 'feather out' the adhesive so even if the solubilised adhesive spread slightly, it would be less visible.

Table 5 – Trials set 2 further trials

TRIAL	ADHESIVE LOCATION	METHOD
2c	Front	Softening and mechanical removal with feathering poultice technique
2d	Front	Softening and mechanical removal with feathering poultice techique and no barrier layer

The additional trials were undertaken using steadily larger poultices in an attempt to further spread the remaining adhesive (see Figure 20). This was trialled with a cotton lawn barrier layer (2c), and with no barrier layer (2d) to see if capillary action was significantly improved (see Table 5). Three successively larger poultices were used and replaced every half an hour, so the treatment was half an hour longer than the previous trials.

Figure 20 – 'Feathering' poultice 2d (no barrier layer)



Both trials were successful in reducing the darkening of the silk due to the laterally spread adhesive, with little to no visible darkened areas (see Figure 21). The cotton lawn barrier trial was slightly more successful in decreasing visual darkening and did not require cleaning after treatment.

Figure 21 – Trial 2c before and after treatment

Before Treatment *After Treatment*

5.7 Trials for both the front and back adhesive

If the front and back of *Golden Tangram* are to be treated separately, one would need to combine the two most successful methods – effectively undertaking two treatments. An overall treatment would be more efficient in terms of time and work required and could also potentially remove more adhesive.

5.7.1 Method

Table 6 – Trial set 3

TRIAL	ADHESIVE LOCATION	METHOD
3a	Front and back	Softening and mechanical removal of adhesive on front, followed by vacuum suction table
3b	Front and back	Immersion

Method 3a utilised the suction table to draw solvent through the mock-up to minimise and control the lateral movement of the solubilised adhesive. Prior to this treatment, the front adhesive was reduced mechanically as per trial set 1. The mock-up was then placed on top of a cotton lawn barrier on the suction table and ethyl acetate was dropped through from the front to the back. No mechanical action was used.

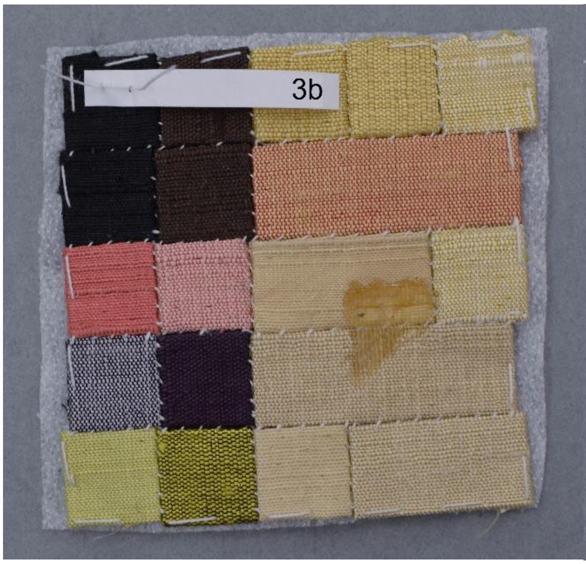
Method 3b used immersion cleaning. The mock-up was immersion cleaned in ethyl acetate. It was given two 10-minute baths in the solvent, and then was turned over after 5 minutes each time. No additional mechanical action was used on the mock-up, but the solvent was kept moving through the object throughout by tilting the container back and forth. After the treatment, the waste solvent was removed, the mock-up blotted with blotting paper and then left to dry in a fume cupboard.

5.7.2 Results

Method 3a gave the least successful results of all the trials. Only minimal adhesive was removed, and this only occurred with continual saturation of the mock-up with solvent. This was probably because the suction did not allow for sufficient contact time between the solvent and adhesive. Also, the mock-up was visibly distorted after the treatment as the front silk layers had been pulled by the suction and had come into contact with the back adhesive, so the centre of each silk piece was indented. This method is not suitable for *Golden Tangram* as it is not effective at removing the adhesive and causes significant distortion.

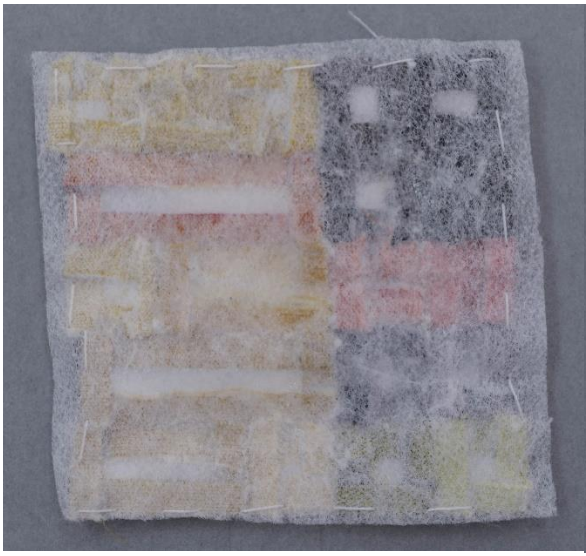
The immersion treatment of 3b was the most successful of all the trials. It visibly removed the most adhesive and the original handle of the materials was restored (see Figure 22). The FTIR spectrum of the front was virtually identical to that of the mock-up before it was coated with adhesive (see Figure 23), and the spectra from the back showed no evidence of remaining nitrogen. In addition to this, the treatment was the quickest and easiest to carry out.

Figure 22 – Trial 3b before and after treatment

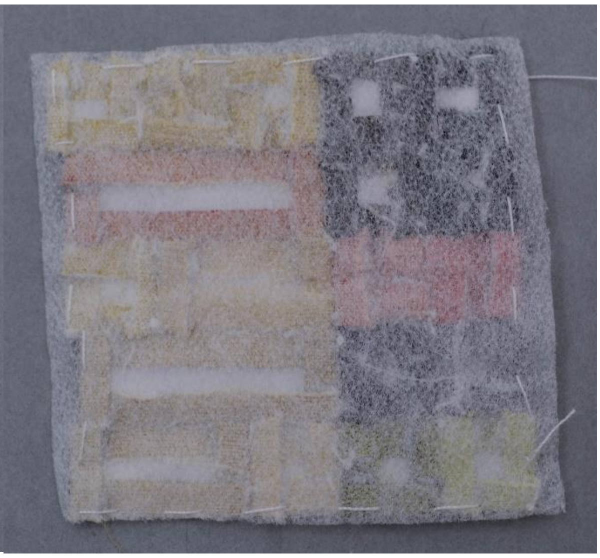


Before treatment front

After treatment front

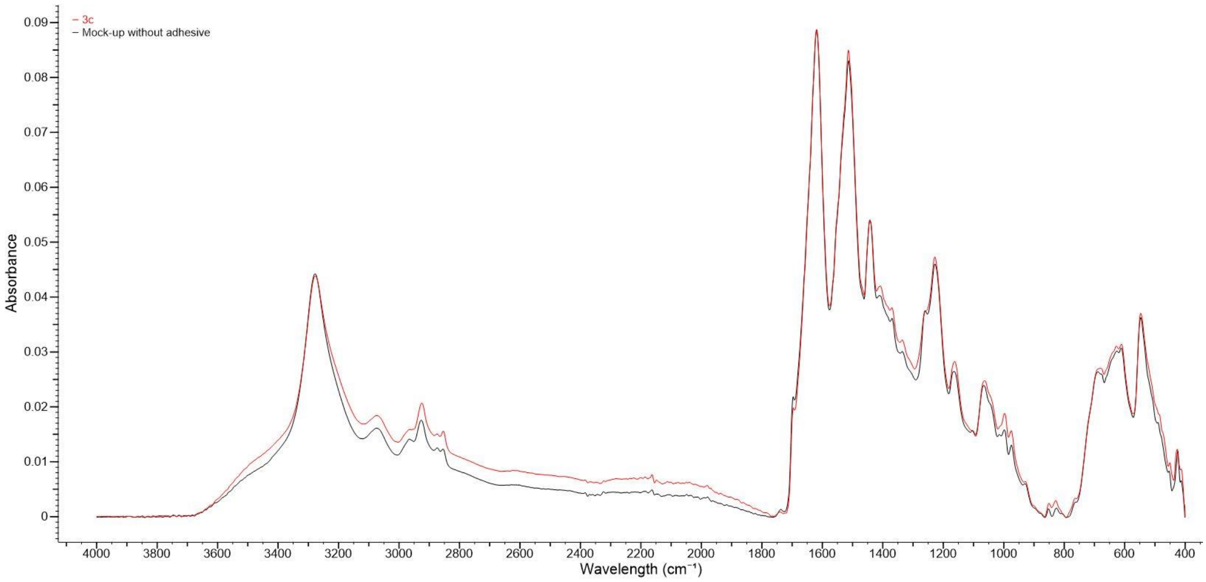


Before treatment back



After treatment back

Figure 23 – FTIR results of 3b vs mock-up front without adhesive



5.7.3 Discussion

An immersion treatment may be a suitable treatment option for *Golden Tangram,* which is in good condition and can withstand a solvent immersion treatment. However, it would require extensive dye fastness testing which would be difficult given the good condition of the silk pieces. It would be necessary to ascertain that all of the silk pieces are indeed silk, as certain semi-synthetic fibres can be dissolved or swell in particular solvents.[113] This would possibly be quicker to do using FTIR analysis than microscopy.

5.8 Conclusion

Trial 1c was deemed to be a successful poultice method for removing the adhesive on the front of *Golden Tangram.* The adhesive was softened with a 'poor' solvent using a poultice and mechanically reduced with a metal spatula. The remaining adhesive was then removed using successively larger poultices with a 'good' solvent. This method requires time and monitoring but is still easy to do. It would only require dye fastness testing of one or two colours given the location of the front adhesive on the object.

However, a successful poultice method for the adhesive on the back was not found and would require further experimentation. The most successful method, 2a, whereby a single poultice with a 'good' solvent was applied on a cotton lawn barrier, was effective in removing

[113] Timár-Balázsy and Eastop, 58.

adhesive, but resulted in unsightly darkening of the edges of the silk pieces on the front. It is possible, however, that this could be reduced by following this with poultice method 1c on the front of *Golden Tangram*, but this has not been tested.

The most effective method was 3b, immersion. It was relatively quick and simple to do. However, it would require the purchase of a larger quantity of solvent. One would also need to consider dye fastness testing and fibre ID, which would be time consuming and difficult given the good condition of *Golden Tangram*.

Chapter 6: Conclusion

6.1 Introduction

In this chapter, the results of the analysis and trials carried out are reviewed and used to form conclusions that will fulfil the aims of the dissertation:

- To enable the future treatment of *Golden Tangram*.
- To contribute to the limited information on the cleaning of multi-layered textiles.

6.2 Treatment proposal for *Golden Tangram*

6.2.1 Introduction

The following treatment options have been informed by the results of the trials and analysis carried out in Chapters 4 and 5. The results from Chapter 4 have been used to inform the future stability of the adhesive and thus how desirable it is to remove it beyond improving the visual aesthetic. The results from Chapter 5 have been used to evaluate the cleaning efficiency and potential risks of the chosen possible treatment methods.

6.2.2 Treatment aims

As per Chapter 4, it is likely the adhesive will continue to deteriorate, and it is therefore likely safest for the long-term stability of *Golden Tangram* to remove as much adhesive as possible. The aims are two-fold.

- To remove the adhesive on the front to reduce visual disfigurement.
- To remove the adhesive from the back to reduce risk of degrading adhesive promoting deterioration of the textiles.

While removing as much adhesive as possible is ideal, the method used to do this could pose risks to the object. To enable a fully informed decision to be made, two different treatment options are suggested. It is important this decision is made by all the stakeholders so that treatment benefits the long-term preservation of the object and respects the policies of the Whitworth and the wishes of Paula Day, Lucienne Day's daughter.

6.2.3 Treatment options

The sections below summarise the treatment options proposed for *Golden Tangram*. Full treatment instructions and time and cost estimates are in Appendices 5 and 6. Different solvents will be required for *Golden Tangram* than were used for testing. The solubility tests in Chapter 4 showed that IDA softened the adhesive similarly to the way the 5:1 mixture of IDA:acetone did to UHU hart, and isopropanol most effectively solubilised it. The treatment times required may be longer than in the testing as the degradation of the adhesive has reduced its solubility. It is therefore recommended that the treatments are monitored throughout and the treatment time lengthened if necessary for effective results.

6.2.3.1 Treatment option 1 – method 2c

Method 2c involves using a poultice first to soften the adhesive on the front so it can be reduced mechanically, and then using another poultice to solubilise and draw out the remaining adhesive. As per the method described in Chapter 5, a 'feathering' technique should be used for the second poultice to remove maximum adhesive and minimise visual disfigurement.

This option is a minimal treatment that will only tackle the adhesive on the front of the object. The focus is to reduce the visual disfigurement caused by the adhesive and its discolouration and remove the adhesive itself to reduce the risk of future physical deterioration of the silk. Before undertaking this treatment, the yellow silk where the adhesive is located and any adjacent colours of silk should be tested for dye fastness in IDA and isopropanol. If the dyes are not fast, alternative solvents can be tested (see solubility results in Chapter 4).

This option should reduce the amount of adhesive on the front. While the method has not been tested using a discoloured adhesive, if the staining caused is not totally removed then the 'feathering' method should reduce the visual disfigurement. The poultice method uses a minimal amount of solvent, with minimal risks of the adhesive moving further into the object or dye bleed. However, the majority of the adhesive, which is on the back, would remain in place, so there would still be a risk of long-term degradation resulting from further deterioration of the adhesive.

6.2.3.2 Treatment option 2 – methods 2c and 3b

This option involves following the 'feathering' poultice method of 2c with full immersion in solvent (method 3b) for maximum removal of the adhesive. Method 3b (immersion) effectively removed the adhesive from the front and back of the mock-ups. However, given the degradation of the adhesive in *Golden Tangram*, possibly it would not solubilise as easily. Undertaking the poultice method 2c would increase the probability of removing the staining on the front.

This more extensive treatment aims to remove as much adhesive as possible from the front and back of the object and minimise the risk of further degradation in the long term. Before undertaking the treatment, the yellow silk where the adhesive is located, and any adjacent colours of silk should be tested for dye fastness in IDA. Every silk colour, and the bias binding, should be tested for dye fastness in isopropanol. The solubility of the adhesive used in the fusible lining should be tested with small swabs of isopropanol. If the dyes are not fast, or the lining adhesive is soluble in isopropanol, an alternative solvent should be used (see solubility results in Chapter 4).

This method should remove the maximum amount of adhesive, and potentially more of the staining, with minimal risk of ringing. It relies on full solubilisation of the adhesive and the staining. There is some risk of adhesive moving through the object, but this is minimised by keeping the solvent moving and doing two baths which should 'rinse' the object. The method requires significantly more testing, which would be time consuming and difficult given the good condition of the object. Also, it may not be possible to solubilise the adhesive without also solubilising the adhesive of the fusible lining. In this case, temporarily releasing the bias binding on the back and replacing the fusible lining after the treatment may need to be considered.

6.3 Cleaning multi-layered textiles

6.3.1 Introduction

As per Chapter 2, there is very little information on the cleaning of multi-layered textiles. The majority of case studies involve separation of the layers. This option is not available for objects like quilts or patchworks, such as *Golden Tangram*, where there is extensive stitching throughout the object, and not just at the edges. Removing this stitching to separate the layers may be physically possible, but would not be ethically appropriate, and would be very time consuming. Instead, the object needs to be treated as a whole object. Case studies of such objects showed examples of immersion cleaning, and one semi-localised stain removal. However, there were no discussions of the potential risks of these treatments and why they may or may not be suitable for a multi-layered object, its construction or the type of staining/soiling that needs to be removed.

The results of the adhesive removal trials undertaken in this dissertation can be used to evaluate some of these risks and the suitability of the different methods for various multi-layered textiles.

6.3.2 Object construction

The construction of the multi-layered textile is likely to be the reason why it needs to be treated as a whole object and not deconstructed. This construction is also the source of the two biggest treatment risks.

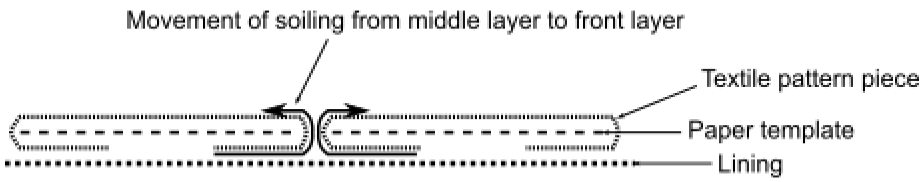
- Mechanical damage from tension caused by differential shrinkage/growth of the different materials or layers.
- Movement of the soiling or staining between the layers.

Solvent treatments are arguably more suitable than aqueous treatments for multi-layered textiles as they do not swell the textile fibres.[114] The immersion trial (3b) carried out in Chapter 5 did not result in any shrinkage or growth, or notable tension between the layers. However, solvent suitability will still depend on the type of soiling, materials, and the condition of the object.[115]

In the adhesive removal trials for the treatment of *Golden Tangram*, the number of textile pattern pieces within the object was also found to be an issue. As found in trial set 2, when the adhesive was effectively solubilised with a localised treatment, it moved both laterally and downwards. This occurred where the fabric had been turned under, i.e. the edges of the patchwork pieces, where the same piece of fabric is effectively on two different layers, promoted movement through these two different layers (see Figure 24).

[114] Timár-Balázsy and Eastop, 175.
[115] Ibid., 176.

Figure 24 – Soil movement through layers of patchwork



The lateral movement of the adhesive can be partially controlled by various methods, but these do not control the downward movement. Using a poultice on this type of textile would require a secondary poultice treatment on the other side to reduce the adhesive that has moved downwards. Alternatively, using a solvent that does not fully solubilise the adhesive could limit movement, but it would limit the capillary action, reducing the poultice's effectiveness. Unless the poultice's capillary action is strong enough to prevent any downward movement, an overall treatment, i.e. immersion, would be more appropriate for the object, assuming it can physically withstand this.

6.3.3 Type of soiling or staining

None of the multi-layered textile case studies deal with adhesive residue, but rather mostly with water-soluble staining. There are some differences between removing adhesive and water-soluble staining, as adhesive is thicker, with larger particles that are not so readily solubilised.

A key difference is the time required for effective solubilisation of the adhesive when it is not immersed in the solvent. The trials undertaken reflected this as dropping solvent through the object on a vacuum suction table was less effective than the poultice treatments, which allow for a longer contact time with volatile solvents. Likewise, the methods used to minimise lateral movement of the adhesive were less effective. The double poultice method did not allow sufficient contact time between the solvent and the adhesive. The dry and wet halos were ineffective, in part due to lack of contact between the dry portions of the poultice and the object, but perhaps also as the adhesive, even when solubilised, did not move easily through the textiles and could not be directed by the poultice capillary action.

The trials suggested that a vacuum suction table treatment is not suitable for multi-layered textiles soiled with adhesive for this reason. It may, however, be more suitable for more readily solubilised soiling or staining, although further testing would be required to ensure the soiling does move through the entire object and there is no lateral movement within the hidden layer.

6.3.4 Suitability of different cleaning methods

One issue regarding the case studies reviewed is that while the methods used were partially justified, there were no details of any testing or consideration of alternatives. In fairness, this additional testing may not have been necessary given the soiling/staining type and the experience of the conservators. However, there still has been no direct comparison between the most common textile conservation cleaning methods with regards to their use on multi-layered textiles. This dissertation could effectively be a preliminary investigation to compare these methods – immersion, suction table and poulticing – albeit under very specific conditions.

In this instance, where the soiling was an adhesive, immersion was the most effective method, resulting in maximum removal of soiling, no visible ringing or movement of any residue remaining, and also the most efficient in terms of time and labour. However, immersion would not be suitable or even necessary for all soiled multi-layered textiles.

Using a vacuum suction table is not recommended for multi-layered textiles. The amount of suction required to control the solvent movement results in distortion of the textile, with no certainty the soiling will move all the way through the textile.

Poulticing, however, is a viable option for many multi-layered textiles, particularly objects with only very localised staining, even if this is on both sides. One would need to consider the potential direction of the solubilised soiling. For a quilt, this is more likely to be lateral, whereas, as previously noted, a patchwork construction can encourage movement throughout the layers. However, even if there is adhesive movement from one side to the other, poulticing on both sides may be able to reduce the total residue and minimise visual disfigurement.

6.3.5 Suitability of poultice methods

Several methods have been developed to control ringing when using a poultice, some of which were trialled for this dissertation, including using a dry halo, a wet halo, and the double poultice method. These have all been proven to work effectively with different soiling/staining, but were not suitable for this particular project for various reasons.

The dry and wet halo methods were not effective as the dry sepiolite did not have enough weight for good contact and efficient capillary action. They could be more effective if the dry sepiolite is made slightly wet to weigh it down. However, there is also the issue of the adhesive being difficult to solubilise – the solubilised adhesive is not easily directed by the differential capillary action, and there will likely be remaining residue that will be visually apparent even if lateral movement is reduced. The double poultice method was the least effective as it did not allow enough contact time with the solvent for the adhesive to solubilise sufficiently.

Consequently, a method of 'feathering' out the remaining adhesive was devised. 'Feathering' out methods are commonly used in localised cleaning treatments. They can be done while swabbing and blotting with solvent, on a suction table, and even with poulticing. However, these methods usually rely on the conservator being able to see the stain and the movement of the residue as the treatment is being carried out. They therefore tend to be limited to clear poultice substances such as Laponite (hydrous sodium lithium magnesium silicate).[116]

These poultice materials, while theoretically best for 'feathering', are not necessarily the most effective or suitable for use on the object type, materials or type of soiling. The 'feathering' technique developed for this dissertation for use with sepiolite, a totally opaque substance, can be used with any non-transparent poultice. It requires more planning than other feathering techniques, but should effectively thin out the area of remining soiling or staining so it is less visually apparent. It is possible that, as the process is undertaken without being able to see the staining, the 'feathering' itself may be less effective than with a transparent poultice material, but the overall removal of adhesive should be greater as the method allows for the best poultice material to be used, regardless of transparency.

---

[116] Flora Nuttgens, "An Evaluation of the Potential of High-Concentration Laponite Poultices to Prevent Ringing in Localise Cleaning of Historic Textiles," (PGDip, the Textile Conservation Centre, the Courtauld Institute, 1999), 33.

6.3 Recommendations for future research

- Further research could be undertaken into the identification of degraded commercial adhesives. There are several studies regarding the artificial ageing/degradation of conservation adhesives and these could be replicated with commercial adhesives.

- More quantitative research could be undertaken to compare different methods of poultice cleaning for multi-layered textiles. The methods used in this dissertation could be repeated with more standardised replicates so that results could be compared and evaluated in a statistically significant way.

Bibliography

Unpublished Sources

Clive-Powell, Kate. "Can Textile Conservation Inform Textile Art?" MPhil dissertation, Centre for Textiles Conservation, University of Glasgow, 2015.

Connolly, Danielle. "The Textile Conservator's Role in the Conservation of Contemporary Textile-Based Art." MPhil dissertation, Centre for Textiles Conservation, University of Glasgow, 2012.

Nuttgens, Flora. "An Evaluation of the Potential of High-Concentration Laponite Poultices to Prevent Ringing in Localise Cleaning of Historic Textiles." PGDip, the Textile Conservation Centre, the Courtauld Institute, 1999.

Sam, Louise Wing-ah. "An Investigation into the Modification of Methods to Improve the Performance of Poultice Cleaning on Textiles." MA dissertation, The Textile Conservation Centre, University of Southampton, 2003.

Thompson, Karen. "An Investigation into the Use of Poultices for Removing Adhesives from Textiles?" PGDip report, Textile Conservation Centre, Courtauld Institute of Art, 1993.

Secondary Material

Ayre, Wayne Nishio, Stephen P. Denyer, and Samuel L. Evans. "Ageing and Moisture Uptake in Polymethyl Methacrylate (PMMA) Bone Cements." *Journal of the Mechanical Behavior of Biomedical Materials* 32 (2014): 76–88. Accessed June 7, 2018. DOI: 10.1016/J.JMBBM.2013.12.010.

Ballard, Mary W. "The Removal of Crosslinked Synthetic Latex from Carpets: Preliminary Results." In *ICOM-CC 8th Triennial Meeting, Sydney, Australia 6-11 September 1987, Preprints*, edited by Kirsten Grimstad and JoAnn Hill, 331-338. International Council of Museums, 1987.

Berthumeyrie, Sebastien, Steve Collin, Pierre-Olivier Bussiere, and Sandrine Therias. "Photooxidation of Cellulose Nitrate: New Insights into Degradation Mechanisms." *Journal of Hazardous Materials* 272 (2014): 137–47. Accessed June 7, 2018. DOI: 10.1016/J.JHAZMAT.2014.02.039.

Carlson, Julia. "A Sticky Situation: A Different Method for Removing Adhesive from an Early 17th-Century Carpet." In *ICOM-CC 18th Triennial Conference Preprints, Copenhagen, 4-8 September 2017,* edited by J. Bridgland. Paris: International Council of Museums, 2017.

Casey, Andrew. *Lucienne Day: In the Spirit of the Age*. Woodbridge: Antique Collectors' Club, 2014.

Chester, Alison, and Dinah Eastop. "The Problem of Common Solubility Parameters: The Removal of Natural Rubber Adhesive Residues from a Painted Silk Banner." In *Resins Ancient and Modern: Pre-Prints of the SSCR's 2nd Conference Held at the Department of Zoology, University of Aberdeen, 13 - 14 September 1995*, edited by Margot M. Wright and Joyce Townsend, 47–51. Edinburgh: SSCR, 1995.

Davies, Laura, and Jackie Heuman. "Meaning Matters: Collaborating with Contemporary Artists." In *Modern Art, New Museums: Contributions to the 2004 IIC Congress, Bilbao*, edited by Ashok Roy and Perry Smith, 30–33. London: International Institute for Conservation of Historic and Artistic Works, 2004.

Derrick, Michelle R., D. S. James, and M. Landry. *Infrared Spectroscopy in Conservation Science*. Los Angeles: Getty Conservation Institute, 1999.

Dole, P., and J. Chauchard. “Thermooxidation of Poly(Ethylene-Co-Methyl Acrylate) and Poly(Methyl Acrylate) Compared to Oxidative Thermal Aging of Polyethylene.” *Polymer Degradation and Stability* 53, no. 1 (1996): 63–72. Accessed June 7, 2018. DOI: 10.1016/0141-3910(96)00026-2.

Ellis, Shirley. “Disaster Recovery at the University of Alberta, or, Every Flood has a Silver Lining.” *Journal of the American Institute for Conservation* 39, no.1 (2000): 117-126. Accessed July 1, 2018. DOI: 10.1179/019713600806113365.

Down, Jane L. *Adhesive Compendium for Conservation*. Ottawa: Canadian Conservation Institute, 2015.

Down, Jane L, Maureen A Macdonald, Jean Tétreault, and R. Scott Williams. “Adhesive Testing at the Canadian Conservation Institute: An Evaluation of Selected Poly(Vinyl Acetate) and Acrylic Adhesives.” *Studies in Conservation* 41, no. 1 (1996): 19-44. Accessed June 2, 2018. https://www.jstor.org/stable/pdf/1506550.

Feller, R. L., and M. Wilt. *Evaluation of Cellulose Ethers for Conservation*. Los Angeles: The Getty Conservation Institute, 1990.

French, Ann. “Modern and Contemporary Textile Art: Issues for Textile Conservators.” In *Textile Conservation: Advances in Practice*, edited by Frances Lennard and Patricia Ewer, 283–90. Oxford: Butterworth-Heinemann, 2010.

French, Ann. “Textile or Art? The Conservation, Display and Storage of Modern Textile Art.” *Studies in Conservation* 49, no. 2 (2004): 34–38. Accessed January 21, 2018. DOI: 10.1179/sic.2004.49.s2.008.

Gorassini, Andrea, Gianpiero Adami, Paolo Calvini, and Alessandro Giacomello. “ATR-FTIR Characterization of Old Pressure Sensitive Adhesive Tapes in Historic Papers.” *Journal of Cultural Heritage* 21 (2016): 775–85. Accessed March 18, 2018. DOI: 10.1016/j.culher.2016.03.005.

Horie, Velson. *Materials for Conservation: Organic Consolidants, Adhesives and Coatings*, 2nd edition. Abingdon: Routledge, 2010.

Heuman, Jackie, and Kate Garland. “A Poultice Technique for the Removal of Cellulose Nitrate Adhesive from Textiles.” *The Conservator* 11, no. 1 (1987): 30–33. Accessed June 12, 2018. DOI: 10.1080/01410096.1987.9995023.

Jackson, Lesley. *Robin and Lucienne Day: Pioneers of Contemporary Design*. London: Mitchell Beazley, 2001.

Learner, Tom. “The Analysis of Synthetic Resins Found in Twentieth Century Paint Media.” In *Resins Ancient and Modern: Pre-Prints of the SSCR’s 2nd Conference Held at the Department of Zoology, University of Aberdeen, 13 - 14 September 19951*, edited by Margot M. Wright and Joyce Townsend, 76–84. Edinburgh: SSCR, 1995.

Lennard, Frances. “Behaving Badly? The Conservation of Modern Textile Art.” *Restauro* 5 (2006): 328–34. Accessed May 11, 2019. http://eprints.gla.ac.uk/44887.

Lomax, Suzanne Quillen, and Sarah L. Fisher. “An Investigation of the Removability of Naturally Aged Synthetic Picture Varnishes.” *Journal of the American Institute for Conservation* 29, no. 2 (1990): 181-191. Accessed June 7, 2018. DOI: 10.2307/3179582.

Marouf, Mohamed, and Medhat Sabers. “Removal of Some Old Resins from Ancient Pile-Textiles: An Applied Study on a Turkish Rug.” In *The Textile Speciality Group Postprints of the AIC 37th Annual Meeting*, edited by Joel Thompson, Amanda Holden, Glenn Petersen, and Sarah Stevens, 116–28. AIC, 2009.

McClean, Lynn, and Elizabeth-Anne Haldane. “Avendale for Reformation: Conservation of a 17th Century Covenanting Banner.” In *Tales in the Textile: Preprints: North American Textile Conservation Conference 2003*, 143–53. Albany, 2003.

Miller, David C., Lynn M. Gedvilas, Bobby To, Cheryl E. Kennedy, and Sarah R. Kurtz. “Durability of Poly(Methyl Methacrylate) Lenses Used in Concentrating Photovoltaic Modules.” *Preprint of Conference Paper to be presented at SPIE 2010 Optics and Photonics Conference, San Diego, California, August 1-5, 2010*. (US Department of Energy, 2010). Accessed June 7, 2018. DOI: 10.1117/12.861096.

Nel, P, C Lonetti, D Lau, K Tam, A Sagona, and R S Sloggett. “Analysis of Adhesives Used on the Melbourne University Cypriot Pottery Collection Using a Portable FTIR-ATR Analyzer.” *AICCM Bulletin* 30 (2007): 27-37. Accessed June 11, 2018. DOI: 10.1016/j.vibspec.2010.01.005.

Noake, Emily, Deborah Lau, and Petronella Nel. “Identification of Cellulose Nitrate Based Adhesive Repairs in Archaeological Pottery of the University of Melbourne’s Middle Eastern Archaeological Pottery Collection Using Portable FTIR-ATR Spectroscopy and PCA.” *Heritage Science* 5, no. 3 (2017). https://doi.org/10.1186/s40494-016-0116-z.

Ragauskien, Daina, Gediminas Niaura, Eimutis Matulionis, and Ricardas Makuska. “Long-Term and Accelerated Ageing of an Acrylic Adhesive Used as a Support for Museum Long-Term and Accelerated Ageing of an Acrylic Adhesive Used as a Support for Museum Textiles” *Studies in Conservation* 51, no. 1 (2006): 57–68. Accessed June 7, 2018. http://www.jstor.org/stable/20619425.

Rice, James W. “An Heirloom Patchwork Quilt and Its Conservation Problems.” *Studies in Conservation* 11, no. 1 (1966): 1–7. Accessed January 21, 2018. DOI: 10.1179/sic.1966.001.

Ritschel, Christina. “The Conservation of the E Dickins Quilt.” *AICCM Bulletin* 32, no. 1 (2011): 203–9. Accessed January 21, 2018. DOI: 10.1179/bac.2011.32.1.025.

Sale, Donald. “Yellowing and Appearance of Conservation Adhesives for Poly(Methyl Methacrylate): A Reappraisal of 20-Year-Old Samples and Test Methods.” In *Proceedings of Symposium 2011: Adhesives and Consolidants for Conservation*. Ottawa: CCI, 2011.

Shashoua, Y., S. M. Bradley, and V. D. Daniels. “Degradation of Cellulose Nitrate Adhesive.” *Studies in Conservation* 37, no. 2 (1992): 113-119. Accessed June 11, 2018. DOI: 10.2307/1506403.

Tímár-Balázsy, Ágnes and Dinah Eastop. *Chemical Principles of Textile Conservation.* Oxford: Butterworth-Heinemann, 1998.

Westerman Bulgarella, Mary, and Susanna Conti. “The Conservation of Savonarola’s Painted Banner.” In *Tales in the Textile: Preprints: North American Textile Conservation Conference 2003*, 135–41. Albany, 2003.

Zięba-Palus, Janina, Sabina Nowińska, and Rafał Kowalski. “Application of Infrared Spectroscopy and Pyrolysis Gas Chromatography for Characterisation of Adhesive Tapes.” *Journal of Molecular Structure* 1126 (December 2016): 232–239. Accessed March 18, 2018. DOI: 10.1016/j.molstruc.2015.11.050.

Websites

"Lucienne Day 1980s." Robin and Lucienne Day Foundation. Accessed March 17, 2018. http://www.robinandluciennedayfoundation.org/.

“Lucienne Day’s Silk Mosaics.” Victoria & Albert Museum. Accessed May 27, 2018. https://www.vam.ac.uk/articles/lucienne-days-silk-mosaic

“Sepiolite”. IMA Europe. Accessed July 11, 2018. https://www.ima-europe.eu/about-industrial-minerals/industrial-minerals-ima-europe/sepiolite.

Further Reading

Beerkens, Lydia, Paulina t' Hoen, Ijsbrand Hummelen, Vivian van Saaze, Tatja Scholte, and Sanneke Stigter. *The Artist Interview: For Conservation and Presentation of Contemporary Art, Guidelines and Practice*. Heÿningen: JAP SAM Books, 2012.

Burnstock, Aviva, and Tanya Kieslich. "A Study of the Clearance of Solvent Gels Used for Varnish Removal from Paintings." In *Preprints of the 11th Triennial Meeting, Edinburgh, Scotland, 1 - 6 September 1996*, edited by Janet Bridgland, 253–62. London: James and James, 1996.

Cannon, Alice. "Interactions Between Adhesives from Natural Sources and Paper Substrates." In *Proceedings of Symposium 2011: Adhesives and Consolidants for Conservation*. Ottawa: CCI, 2011.

Chelazzi, David, Aurelia Chevalier, Giacomo Pizzorusso, Rodorico Giorgi, Michel Menu, and Piero Baglioni. "Characterization and Degradation of Poly(Vinyl Acetate)-Based Adhesives for Canvas Paintings." *Polymer Degradation and Stability* 107 (2014): 314–20.

Evenson, Janet, and Patricia Cox Crews. "The Effects of Light Exposure and Heat-Aging on Selected Quilting Products Containing Adhesives." *Journal of the American Institute for Conservation* 44, no. 1 (2005): 27–38. DOI: 10.1179/019713605806082428.

Garfinkle, Ann M., Janet Fries, Daniel Lopez, and Laura Possessky. "Art Conservation and the Legal Obligation to Preserve Artistic Intent." *Journal of the American Institute for Conservation* 36, no. 2 (1997): 165–79.

Naunton, M. "Use of Gel Poultices for Adhesive Removal." In *Textile Speciality Group Postprints AIC 37th Annual Meeting*, 184–86. AIC, 2009.

Rieppo, L., S. Saarakkala, T. Närhi, H.J. Helminen, J.S. Jurvelin, and J. Rieppo. "Application of Second Derivative Spectroscopy for Increasing Molecular Specificity of Fourier Transform Infrared Spectroscopic Imaging of Articular Cartilage." *Osteoarthritis and Cartilage* 20, no. 5 (2012): 451–59. DOI: 10.1016/J.JOCA.2012.01.010.

Appendix 1: Conserving contemporary textile art, a literature review

Contemporary textile art will be considered as defined by French - art works where the use of textile as a medium is integral to the work, which are to be exhibited as a work of art with no intention of functional use.[117] This review will focus on sources specifically on the conservation of contemporary textile-based art, although some sources dealing with conservation of contemporary art in general will also be included.

There are far more sources on the conservation of contemporary art as a whole than on contemporary textile art specifically. However, as these sources focus mainly on the ethics of the decision-making by the conservator, they can easily be applied to use on contemporary textile art.

Several sources highlight the identification of the materials used in modern art as a particular issue. French states that knowledge of materials is key to predicting likely degradation and inform conservation choices in textile conservation.[118] Clive Powell notes that full documentation of art works is usually only provided if reproductions will be needed,[119] and that even when brand names of products used are known, the contents of these products are rarely disclosed by the manufacturers for commercial reasons.[120] Secondly, even if materials can be identified, they have likely not been chosen with long-term preservation in mind. Lennard states that modern art materials often use contemporary materials that actually degrade more readily than 'traditional' ones.[121]

Another key factor in ethically conserving contemporary art is identifying and considering the meaning and significance of the artwork. Connolly concludes that determining the meaning of an artwork prior to making conservation decisions is vital.[122] Lennard considers this part of the textile conservator's traditional remit – when treating contemporary textile art, reviewing the role and context of the object is in effect, considering the artist's intention for the artwork.[123] Davies and Heuman suggest that the challenge is resolving the inherent

---

[117] Ann French, "Modern and Contemporary Textile Art: Issues for Textile Conservators," in *Textile Conservation: Advances in Practice*, ed. Frances Lennard and Patricia Ewer (Oxford: Butterworth-Heinemann, 2010), 283.
[118] Ann French, "Textile or Art? The Conservation, Display and Storage of Modern Textile Art," *Studies in Conservation* 49, no.2 (2004): 35, accessed January 21, 2018, DOI: 10.1179/sic.2004.49.s2.008.
[119] Kate Clive-Powell, "Can Textile Conservation Inform Textile Art?" (MPhil dissertation, Centre for Textile Conservation, University of Glasgow, 2015), 27.
[120] Ibid, 28.
[121] Frances Lennard, "Behaving Badly? The Conservation of Modern Textile Art," *Restauro* 5 (2006), accessed May 11, 2018, http://eprints.gla.ac.uk/44887.
[122] Danielle Connolly, "The Textile Conservator's Role in the Conservation of Contemporary Textile-Based Art" (MPhil dissertation, Centre for Textile Conservation, University of Glasgow, 2012), 62 .
[123] Lennard.

conflict between conservation, which aims to preserve the past for the future, and contemporary art, which is about its impact in the present.[124]

In conclusion, the conservation of contemporary textile art objects can and should be approached in the same way as the conservation of more traditional heritage textiles objects. However, one needs to be aware of the different issues that will arise when conserving contemporary textile art when following standard conservation procedures. When documenting a contemporary textile art object, the usual material information may be harder to obtain due to the use of unconventional materials or techniques. The significance and context of the object are more complex as they will inevitably be interlinked with the artist's intention for the piece.

[124] Laura Davies and Jackie Heuman, "Meaning Matters: Collaborating with Contemporary Artists," in *Modern Art, New Museums: Contributions to the 2004 IIC Congress, Bilbao*, ed. Ashok Roy and Perry Smith (London: International Institute for Conservation of Historic and Artistic Works, 2004), 33.

Appendix 2: Lucienne Day and her silk mosaics

Lucienne Day (christened Desirée Lucienne Lisbeth Dulcie Conradi) was born in 1917 in Coulsden, Surrey.[125] She attended Croydon School of Art and went on to study design at the Royal College of Art.[126] She came into prominence as one of a new generation of post-war textile designers and believed that good design should be mass-produced for all so it could improve ordinary people's lives. Her breakthrough into the design world was at the Festival of Britain in 1951 with her design 'Calyx', for which she was awarded the International Design Award a year later by the American Institute of Decorators. She continued to win awards for her work throughout her career, working with the likes of Heals and Rosenthal Porzellanfabrik, and expanded into areas of design outside of textiles, including ceramics and wallpaper.[127] She eventually retired from designing in 1999.[128]

In the 1970s, Day stepped away from mass-produced design and started channelling her creativity into a new form of design that she called silk mosaics.[129] At the time, she was working as a consultant to the John Lewis Partnership and had been asked to design the fire shutters for the new store in Newcastle. A visitor to her studio saw the designs and suggested that they were similar to embroidery design, triggering Day's idea for making silk mosaics.[130]

She designed and made hundreds of these mosaics between the mid-1970s and her retirement in 1999. Some were made for exhibitions and eventually purchased for domestic display, but several were designed as major commissions.[131] For example, *Window* for the Queen Elizabeth II Conference Centre in Westminster and *Aspects of the Sun* which is still hanging in the John Lewis store in Kingston. Day called them mosaics as their geometric design and construction resembled the tesserae of Roman mosaics as well as hinting at a connection with architecture and interior design.[132] The silk pieces were always square or rectangular and Day enjoyed the challenge of working within this self-imposed discipline.[133]

---

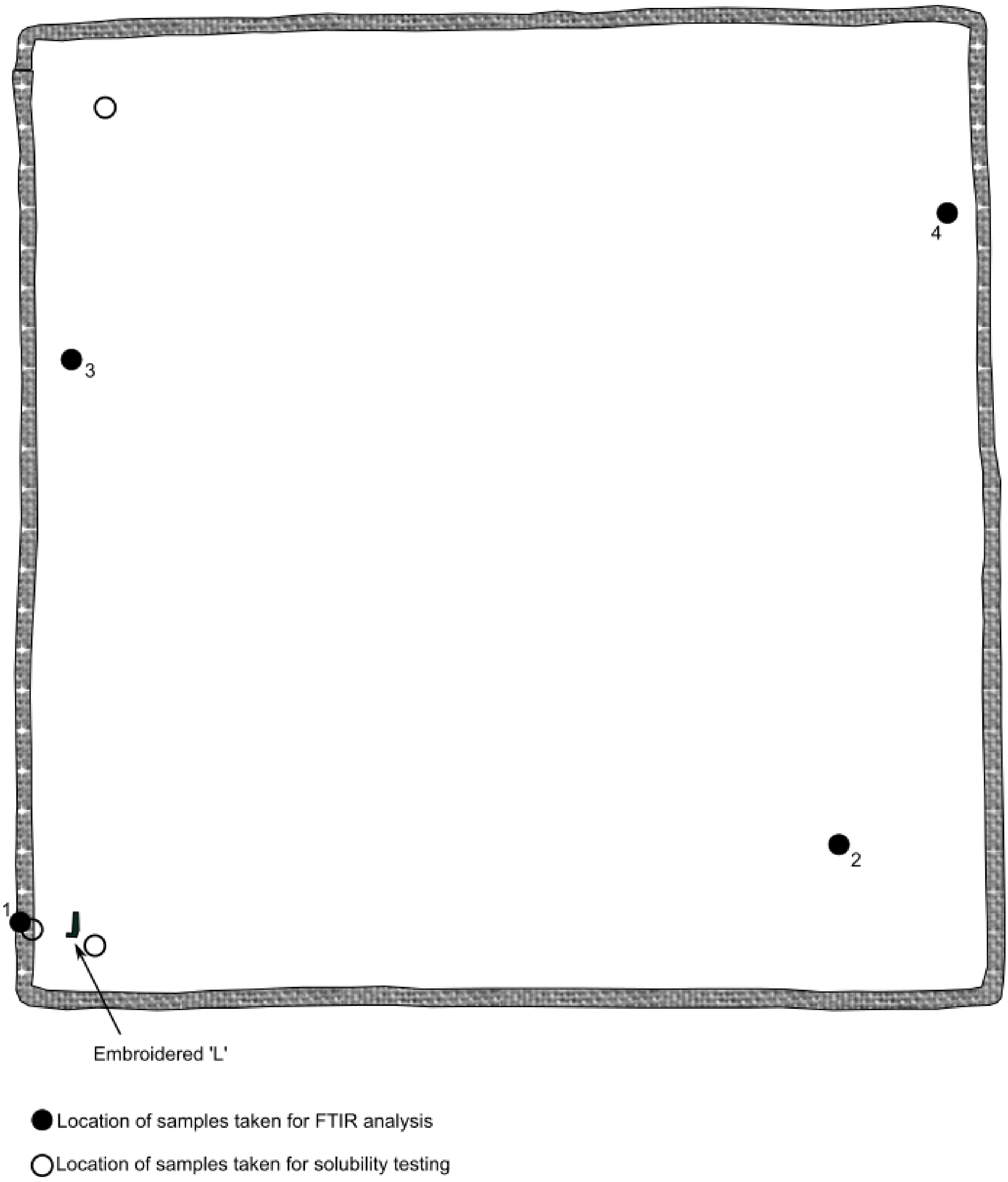
125 Andrew Casey, *Lucienne Day : In the Spirit of the Age* (Woodbridge: Antique Collectors' Club, 2014), 14.
126 Lesley Jackson, *Robin and Lucienne Day: Pioneers of Contemporary Design* (London: Mitchell Beazley, 2001), 11.
127 Casey, 12.
128 Ibid., 110.
129 Ibid., 12.
130 Jackson, 160.
131 "Lucienne Day's Silk Mosaics," Victoria & Albert Museum, accessed May 27, 2018, https://www.vam.ac.uk/articles/lucienne-days-silk-mosaics.
132 Ibid.
133 "Lucienne Day 1980s," Robin and Lucienne Day Foundation, accessed March 17, 2018, http://www.robinandluciennedayfoundation.org/.

The design process started by creating a ‘cartoon’ on graph paper that could be used to match the silk colours to.[134] Day usually used richly-coloured Thai or Indian silks as she liked their texture and felt the iridescence of shot silks (with different coloured warp and weft threads) added dimension to the mosaics.[135,136] The silk pieces were backed to prevent fraying and tacked on to graph paper templates before being hand sewn together with Sylko threads.[137]

While Day made the first mosaics she designed, she eventually employed two seamstresses, including her niece, Karin Conradi.[138] Day considered herself a designer rather than a maker, but she was still in control of the making process and the quality of the finished pieces.[139] She was also keen to distance the mosaics from the craft revival movement despite the traditional paper-piecing patchwork techniques used to construct them. They were very much design-led and not intended to be for functional use but considered artworks.[140] Lucienne was an artist-designer and ensured her mosaics were exhibited at venues with art gallery atmospheres to ensure their significance as artworks rather than craft pieces was clear.[141]

[134] Casey, 232.
[135] Victoria & Albert Museum.
[136] Jackson, 162.
[137] Casey, 232.
[138] Jackson, 160.
[139] Ibid., 162.
[140] Ibid., 160.
[141] Casey, 108.

<u>Appendix 3: Sample location on back of *Golden Tangram*</u>



Appendix 4: Preliminary testing

4.1 Preliminary mock-ups

Simple mock-ups were made for the preliminary tests. A piece of silk was backed with Vlieseline® F220 fusible lining and folded over the edges of a 50mm x 50mm piece of plain white paper. The silk was tacked into place, the folded edges ironed, and then the tacking removed. A 50mm x 50mm piece of the fusible lining was then ironed in place on the back of the mock-up and stitched around the edges. The mock-ups were then coated in the UHU hart adhesive.

4.2 Testing for adhesive movement

Poultices for solubilising the adhesive were tested to see if the adhesive was able to be drawn into the poultice. Two mock-ups were prepared with embedded UHU hart on the back. These were treated with poultices made up from 1:2 sepiolite:solvent that were left on the mock-ups for one hour and covered with polythene. It was found that an ethyl acetate poultice effectively drew up the adhesive, leaving the mock-up more flexible with less visible adhesive. For comparison, an IDA/acetone (which only softens the adhesive) poultice was also tested. This had little to no effect on the adhesive, which softened but remained in place as it was too embedded to remove mechanically.

4.3 Barrier layer – poultice to soften the adhesive

To prevent residue being left on *Golden Tangram* it would be best to use a barrier layer with the poultice. For the poultice to soften the thicker adhesive on the front, the barrier itself does not need to act with capillary action and can just allow solvent vapour to permeate it. Sam recommended Tyvek® as a barrier layer as it demonstrated these properties,[142] and Thompson found that a barrier layer of lens tissue was effective.[143] These barriers were therefore trialled with a poultice to soften the adhesive.

Tyvek® and lens tissue were trialled on mock-ups with thick localised adhesive on the front. The poultices were made up 1:2 sepiolite:IDA/acetone (5:1) and placed on top of the barrier layers, covered and monitored every 15 minutes. It was found that, after 30 minutes, both barrier layers had softened the adhesive enough to be reduced with a metal spatula. The poultice continued to be effective until after one hour, when only embedded adhesive remained which could not be removed mechanically without damaging the silk.

4.4 Barrier layer – poultice to solubilise the adhesive

[142] Sam, 44.
[143] Thompson, 45.

To draw out the embedded adhesive on both the front and the back, the barrier layer needs to allow for sufficient contact between the poultice and the adhesive layer and have good capillary action, aiding that of the poultice. Thompson showed that both lens tissue and moistened filter paper were effective with sepiolite poultices on shellac.[144] These were trialled along with cotton lawn (which had been used by the author in the past) for use with a poultice to solubilise the adhesive.

The three barrier layers were trialled on mock-ups with embedded test adhesive on the back. The poultices were made up with 1:2 sepiolite:ethyl acetate, placed on top of the barrier layers, covered and left for an hour. It was found that while all of the barrier layers allowed some capillary action, the cotton lawn resulted in the least movement of the adhesive through the textile and visibly removed the most adhesive.

4.5 Other parameters

Sepiolite poultices can be moulded to shape – it has been noted that they require a certain depth in order to have maximum capillary action that can also aid in maintaining good contact.[145] It was found in preliminary trials that a minimum depth of 10mm gave good results and was workable considering the small size of the mock-ups.

A 1:2 sepiolite:solvent ratio was used for the initial poultice trials as this was the ratio used by Heuman.[146] However, the 1:2 ratio was found to be a little too dry, which not only limited its malleability but could also reduce contact with the adhesive surface. Therefore, a ratio of 2:5 sepiolite:solvent was decided on for the main testing.

[144] Ibid., 45.
[145] Heuman and Garland, 31.
[146] Ibid., 31.

Appendix 5: Treatment option 1 method and estimates

5.1 Recommended method

- Testing should be carried out prior to treatment as advised in Chapter 6 for this treatment option.
- Mechanical surface cleaning with gentle vacuum suction and a soft brush to remove dusty particulates from the object. This is a precautionary measure to minimise the risk of dust particles becoming stuck to the adhesive as the treatment is carried out.
- The remaining treatment should be carried out in a fume cupboard to contain the solvent vapours, but without extraction to reduce the risk of the poultice drying out.
- Trial method 2c (see Chapter 5) should be used remove the adhesive on the front of *Golden Tangram.*
- A localised poultice treatment to soften the adhesive on the surface so it can be reduced mechanically. The poultice should be made using a 2:5 ratio of sepiolite:IDA. The poultice size should just cover the adhesive area and be placed on top of a Tyvek® barrier layer. The Tyvek® should be larger than the poultice (approximately 100mm x 100mm) to minimise the chance of sepiolite residue on the object. The entire poultice system should be covered with polythene weighed down at the edges to contain the solvent vapours.
- The poultice should be left for half an hour before it is removed and the softened adhesive reduced with a metal spatula. The original Tyvek® layer should be replaced with a new one and the poultice put back in place. This process should be repeated every 15 minutes until one hour and 15 minutes have passed or there is not enough adhesive left on the surface to be easily removed with the spatula.
- A Melinex stencil should be made to the same size as the cotton lawn barrier layer. The area of adhesive should be marked on the Melinex and cut away so a stencil is made. The stencil should be used to mark the adhesive area on the cotton lawn using a pencil. Two area successively larger than this should be drawn around the original area.
- The poultices for the next part of the treatment should be made using 2:5 ratio of sepiolite:isopropanol. They should all be pressed down on to the cotton lawn barrier layer and covered with polythene to contain the solvent vapours.
- The first poultice should cover the smallest stencil shape, and left in place for at least half an hour. Trials in Chapter 5 showed this was sufficient time to solubilise the adhesive, but additional time may be required for the degraded adhesive on *Golden Tangram.* After this time, the poultice should be removed and replaced with one the

size of the middle stencil shape, which should be covered and left for the same amount of time as the first. Finally, the same process should be repeated with the last poultice which should be the size of the largest stencil shape.

- The poultice should then be uncovered and left in place for the solvent to fully evaporate for maximum capillary action. If the fumes are not sufficiently contained by the fume cupboard, the extraction should be turned on.

5.2 Time estimate (hours)

ESTIMATE SHEET - TIME TREATMENT OPTION 1			
Object Number: T.2017.2; CTC.443			**Object size:** 458 x 459 x 27mm (including board)
Object title: *Golden Tangram*	OPTION 1 Lower	 Upper	COMMENTS
Estimate			
Testing	10	14	Fibre ID (FTIR); Dye fastness; Solvent tests
Surface cleaning	1	1.5	Vacuum suction
Softening poultice treatment	1.25	1.5	Preparation and 1 hour treatment (requires monitoring)
Solubilising poultice treatment	2	2.25	Preparation and 1.5 hour treatment (requires monitoring)
TOTAL	14.25	19.25	
Estimate date	14/08/2018		
Estimate prep by	Kim Tourret		

5.3 Cost estimate

ESTIMATE SHEET - COSTS TREATMENT OPTION 1						
Object Number: T.2017.2; CTC.443						**Object size:** 458 x 459 x 27mm (including board)
Object title: *Golden Tangram*	Qty	Unit	Cost per unit	Cost	Supplier	COMMENTS
Sepiolite	0.05	kg	£50.20	£2.51	Sigma Aldrich	Poultice treatments
Industrial denatured alcohol (IDA)	0.04	Litre	£19.56	£0.78	Fisher	Softening poultice treatment
Tyvek®	0.1	m	£1.90	£0.19	Preservation Equipment	Softening poultice treatment
Isopropanol	0.075	Litre	£8.29	£0.62	Kremer Pigmente	Solubilising poultice treatment
Cotton lawn	0.1	m	£10.70	£1.07	Whaleys	Solubilising poultice treatment
Melinex (75 microns)	0.1	m	£0.97	£0.10	Preservation Equipment	Solubilising poultice treatment
			TOTAL COST	£5.27		
			Estimate date	14/08/2018		
			Estimate prep by	Kim Tourret		

Appendix 6: Treatment option 2 method and estimates

6.1 Recommended method

- Testing should be carried out prior to treatment as advised in Chapter 6 for this treatment option.
- Treatment option 1 should be carried out as advised in Appendix 4.
- The entire object should then be placed in a container slightly larger than *Golden Tangram* and immersed in isopropanol under extraction. The object should be left for 5 minutes and then turned over and left for another 5 minutes. The container should be tilted throughout to move the solvent through the object and flush out the solubilised adhesive.
- Then, the object should be moved into a second container so there is no risk of soil deposition. The immersion process should then be repeated using clean isopropanol.
- The object should then be removed and dried with blotting paper, and then left under extraction for the solvent to fully evaporate.

6.2 Time estimate (hours)

ESTIMATE SHEET - TIME TREATMENT OPTION 2			
Object Number: T.2017.2; CTC.443			**Object size:** 458 x 459 x 27mm (including board)
Object title: *Golden Tangram*	**OPTION 1** **Lower**	 **Upper**	**COMMENTS**
Estimate			
Testing	28	35	Fibre ID (FTIR); Dye fastness; Solvent tests
Surface cleaning	1	1.5	Vacuum suction
Softening poultice treatment	1.25	1.5	Preparation and 1 hour treatment (requires monitoring)
Solubilising poultice treatment	2	2.25	Preparation and 1.5 hour treatment (requires monitoring)
Immersion treatment	0.75	1	Preparation and 20 minute treatment
TOTAL	33	41.25	
Estimate date	14/08/2018		
Estimate prep by	Kim Tourret		

6.3 Cost estimate

ESTIMATE SHEET - COSTS TREATMENT OPTION 2						
Object Number: T.2017.2; CTC.443						**Object size:** 458 x 459 x 27mm (including board)
Object title: *Golden Tangram*	**Qty**	**Unit**	**Cost per unit**	**Cost**	**Supplier**	**COMMENTS**
Sepiolite	0.05	kg	£50.20	£2.51	Sigma Aldrich	Poultice treatments
Industrial denatured alcohol (IDA)	0.04	Litre	£19.56	£0.78	Fisher	Softening poultice treatment
Tyvek®	0.1	m	£1.90	£0.19	Preservation Equipment	Softening poultice treatment
Isopropanol	12	kg	£8.29	£99.48	Fisher	Solubilising poultice treatment
Cotton lawn	0.1	m	£10.70	£1.07	Whaleys	Solubilising poultice treatment
Melinex (75 microns)	0.1	m	£0.97	£0.10	Preservation Equipment	Solubilising poultice treatment
Blotting paper	0.5	sheet	£1.49	£0.75	Preservation Equipment	Immersion treatment
			TOTAL COST	£104.13		
			Estimate date	14/08/2018		
			Estimate prep by	Kim Tourret		

Appendix 7: Paula Day questionnaire

1. In Karen Conradi's essay featured in Andrew Casey's book, *Lucienne Day: In the Spirit of the Age,* she mentions that the silk pieces were backed before being tacked on to the paper templates. Do you know what backing was used for this, for example, was it a fusible interlining as used on the reverse of *Golden Tangram*?

I'm afraid I don't know. I could probably introduce you to Karin Conradi, who should be able to answer any technical questions of this kind.

2. I understand that some of the earlier silk mosaics were made by Karen Conradi and Henrietta Brooks. Do you have any information on who the maker of *Golden Tangram* was?

I believe Karin Conradi worked for my mother right up to 1999, when my parents moved to Chichester and my mother retired from design work. I'm pretty sure she made it.

3. *Golden Tangram* was featured on a limited-edition cover of Wallpaper magazine in 2009 and is credited in the magazine as having been made specifically for this purpose. Are you aware if this was indeed the case or if in fact it was made prior to this for a different reason?

Absolutely not! My mother stopped designing silk mosaics in 1999. When she retired from design work she still had many silk mosaics (probably made for exhibitions) which had not been sold. She hung *Golden Tangram* at the top of the stairs to the guest bedroom in my parents' new home in Chichester, which suggests that she rated it highly. I'd assume that, when Wallpaper magazine asked her for a special piece to feature on their cover, she made this available for them to photograph.

4. From the treatment brief for *Golden Tangram*, I understand that it is necessary for the mosaic to remain on the MDF backboard as it was mounted this way by Robin Day, and therefore significant in itself. Was this mounting considered part of the original piece or was it added at a later date?

I don't know when the silk mosaic was mounted, but my mother certainly would not have considered it to be part of the piece. I didn't agree to the silk mosaic being removed from the panel as it is part of its history.
Am I right in thinking that when *Golden Tangram* was photographed for Wallpaper Magazine, it wasn't marked? Or has the image been cropped or perhaps photoshopped to edit it out? This is a conundrum as I very much doubt that my father would have mounted the silk mosaic after it was photographed for Wallpaper magazine (ie in 2009/2010). I suppose this raises a question about whether or not the mark was actually caused by adhesive when it was being mounted, or whether it could have been marked in some other way when it was hanging in the Chichester house after it was photographed for Wallpaper magazine.

5. Did Robin Day mount any other of Lucienne's silk mosaics and if so, what methods did he usually use? Were any other pieces mounted similarly to *Golden Tangram,* adhered to a painted MDF backboard?

Several of my mother's silk mosaics were mounted in a similar way, including some very early ones (*Spring Tree* and *Summer Tree*) in my possession, and the *Decoy and Pond* series of six silk mosaics now owned by V&A Museum. I'm assuming it was my father who mounted them as it is the kind of thing he did round the house, and it would have been he who sawed the board to size in his workshop.

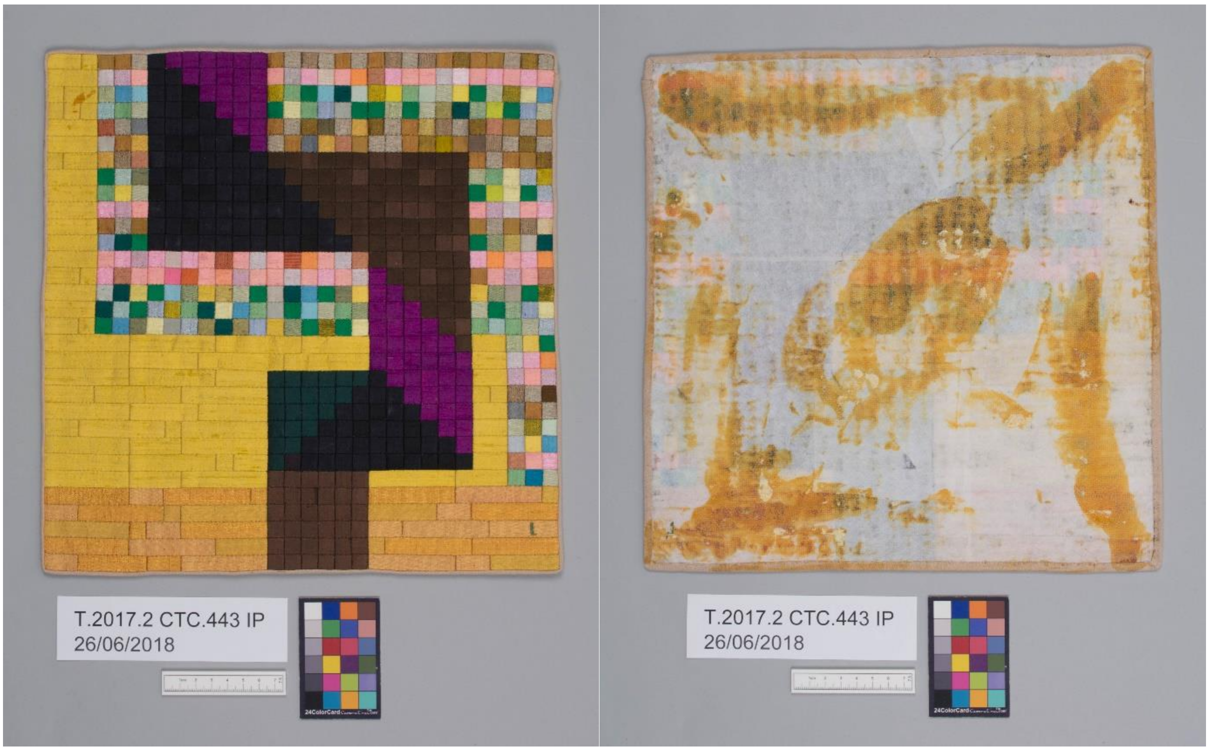
Most of the silk mosaics were not mounted at all. Some have a very slender light baton fixed along the top edge, either with little hooks which could be hung onto panel pins on a wall, or the baton could simply be stuck direct to a wall. I'd guess that these systems were also devised by my father.
I suspect that the question of whether/how best to mount and hang the silk mosaics was never fully resolved. An architect friend of my parents recently told me that he had discussed with my mother how to hang one she gave him, and she asked him to let her know if he came up with a good solution.

6. Are you aware of any particular glues or adhesives that Robin Day used regularly? In particular, the glue that was used for mounting *Golden Tangram*.

Cow Gum was used a lot in my parents' studio. (My father used strong woodworking adhesives, but obviously not for this job).

Appendix 8: Photographs of *Golden Tangram*

8.1 Overall front and back of *Golden Tangram* (removed from board)

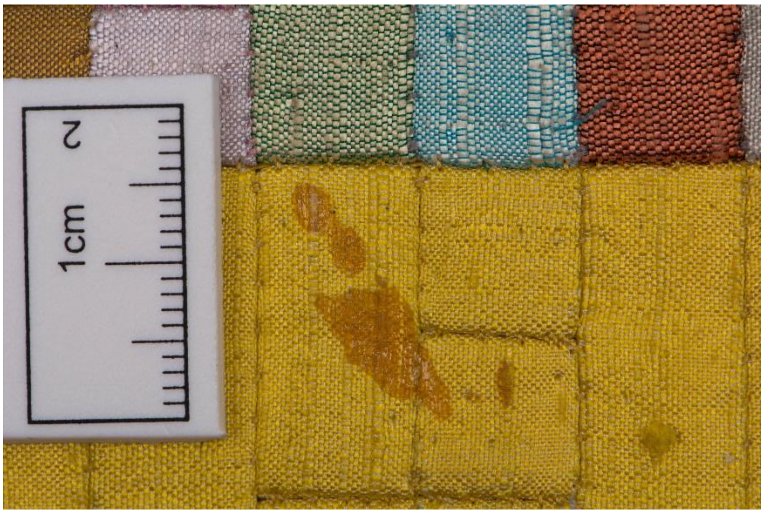


Design © The Robin and Lucienne Day Foundation

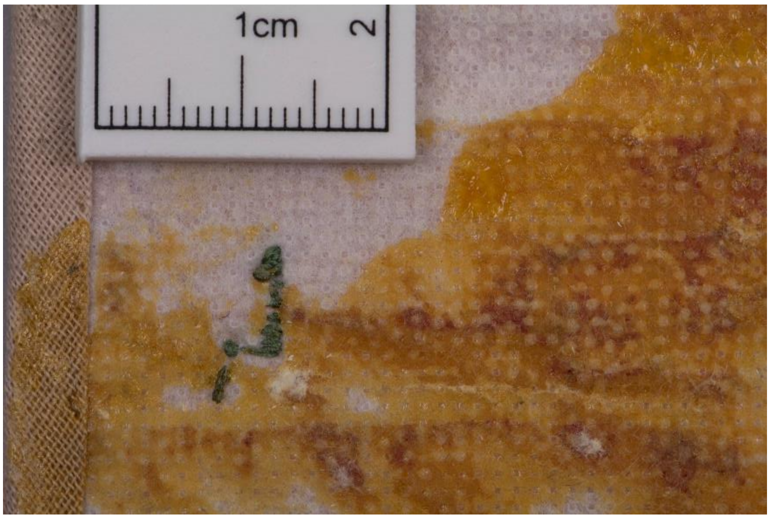
8.2 Overall front and back of the backing board

Design © The Robin and Lucienne Day Foundation

8.3 Adhesive on the front



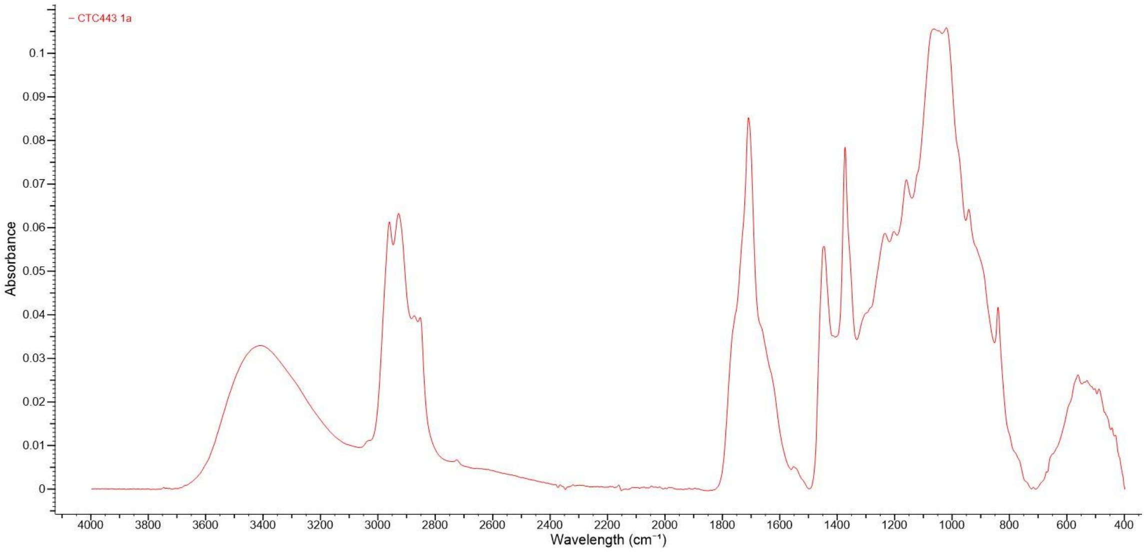
8.4 Adhesive on the back



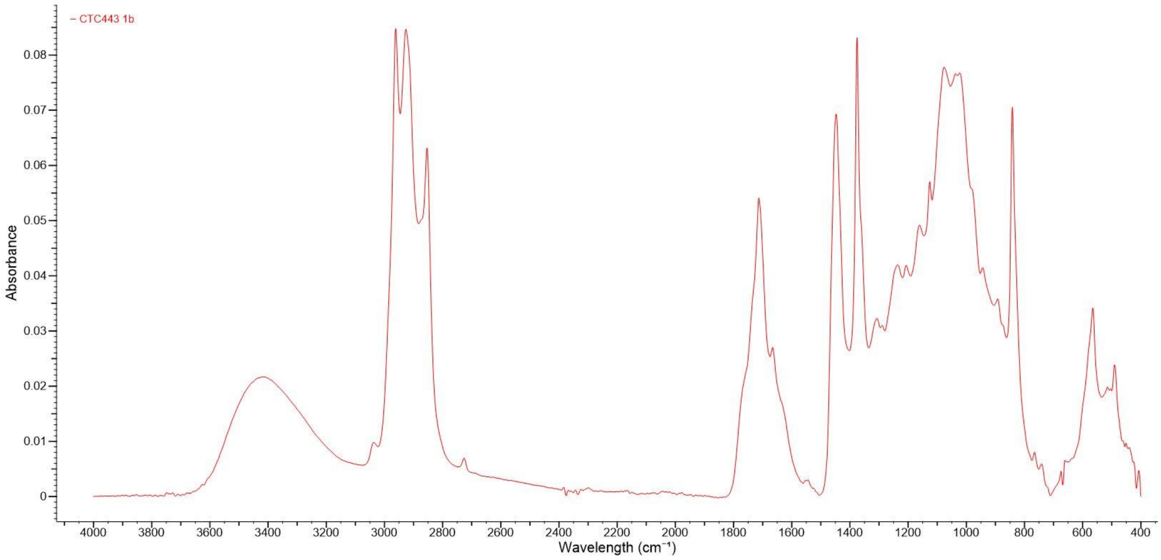
8.5 Adhesive on the backing board

<u>Appendix 9: FTIR Results from *Golden Tangram* adhesive samples</u>

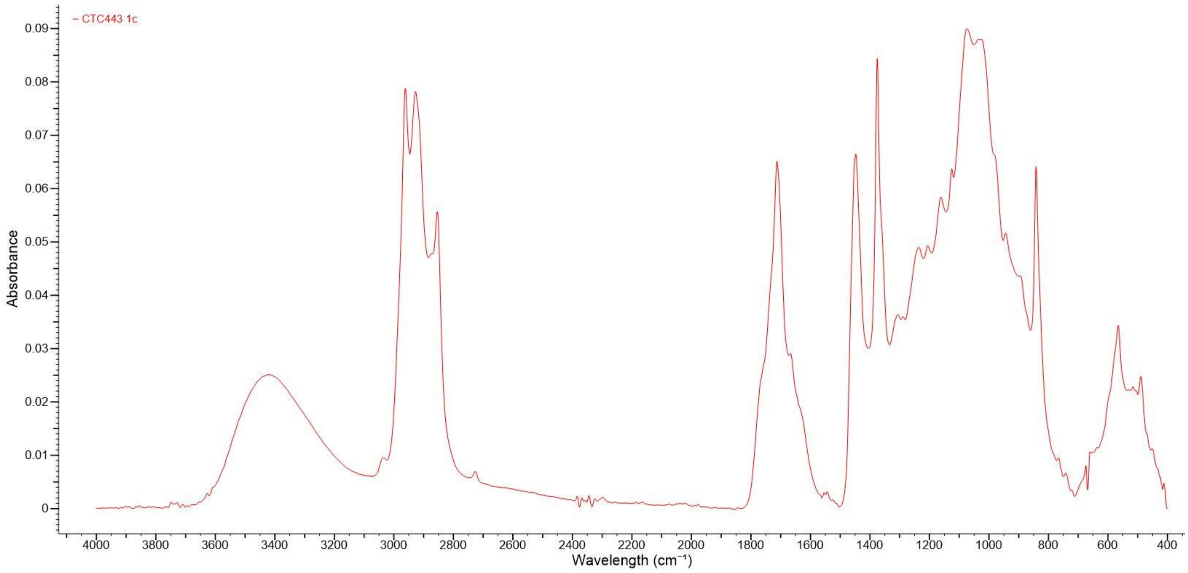
1a



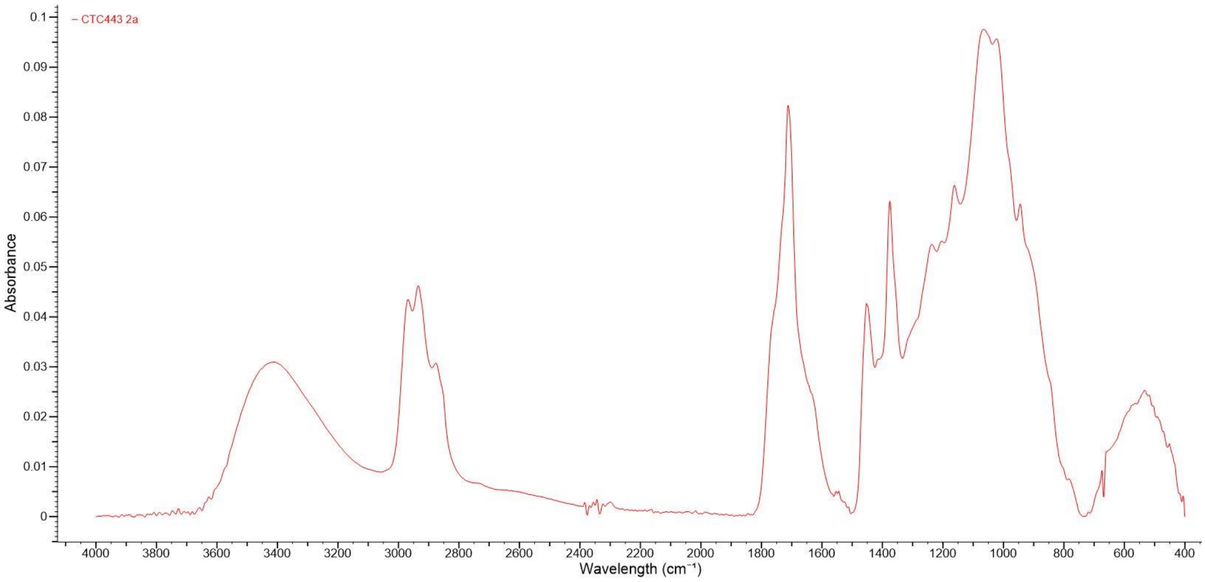
1b



1c

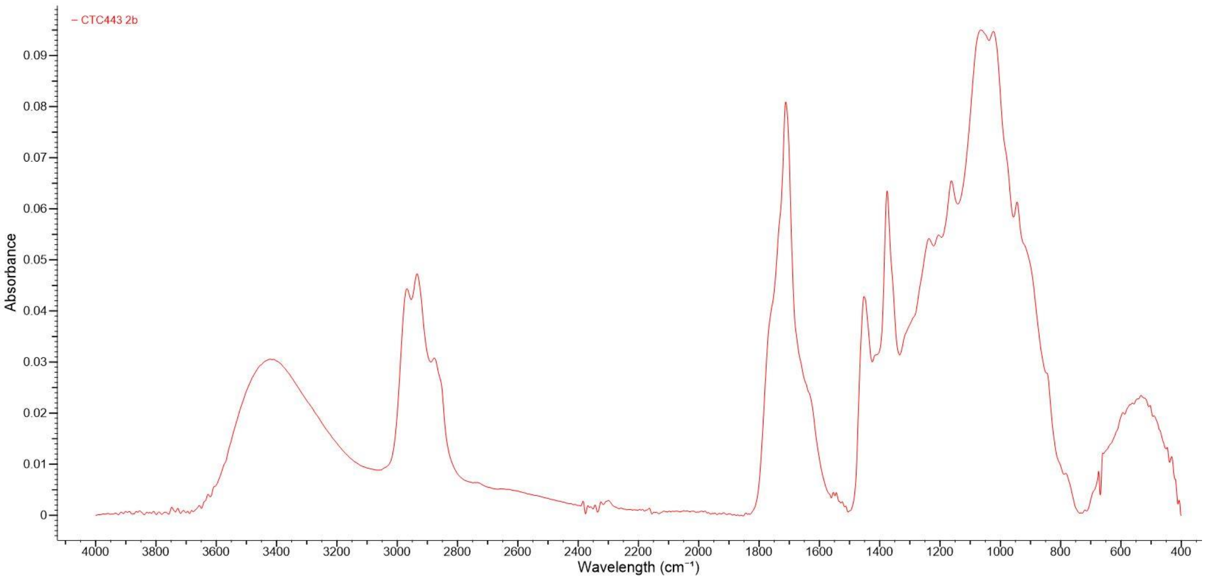


2a



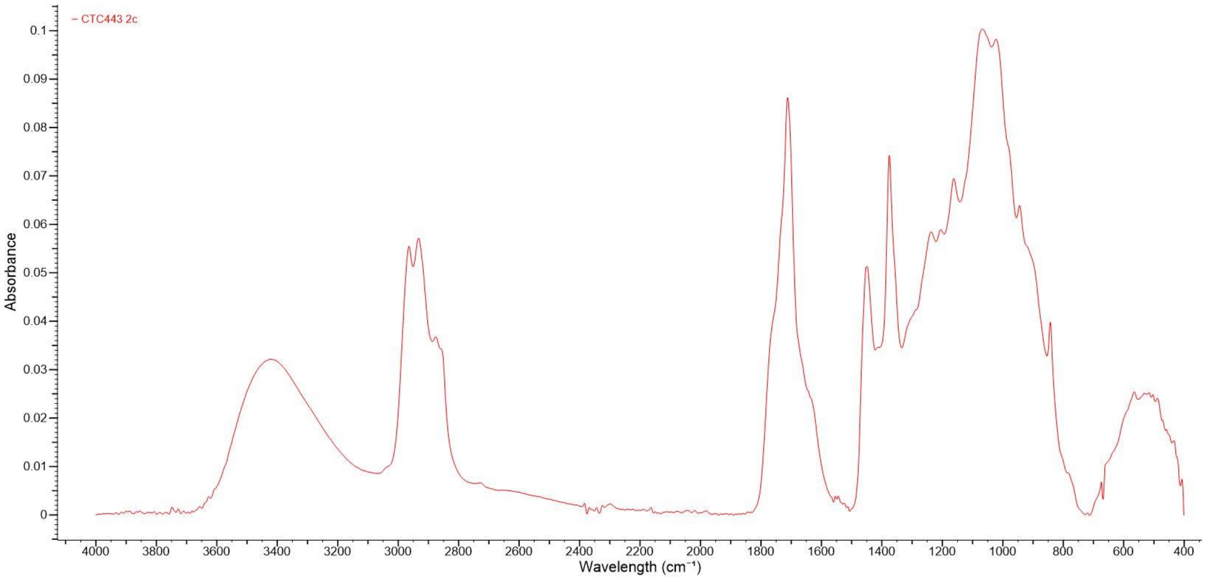
– CTC443 2a
Absorbance
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

2b



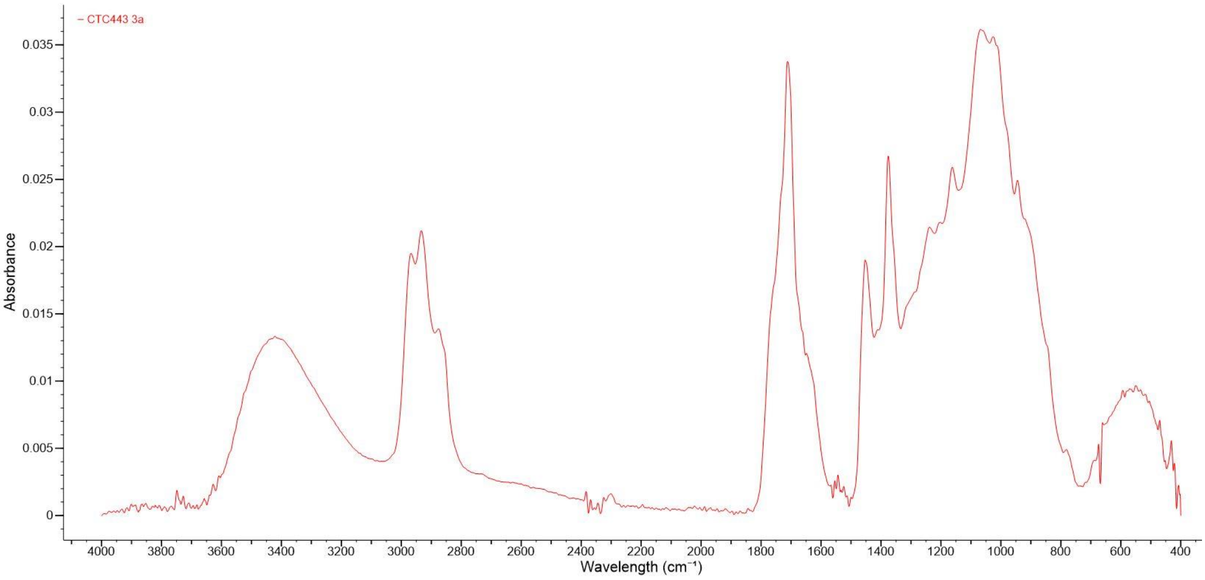
– CTC443 2b
Absorbance
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

2c



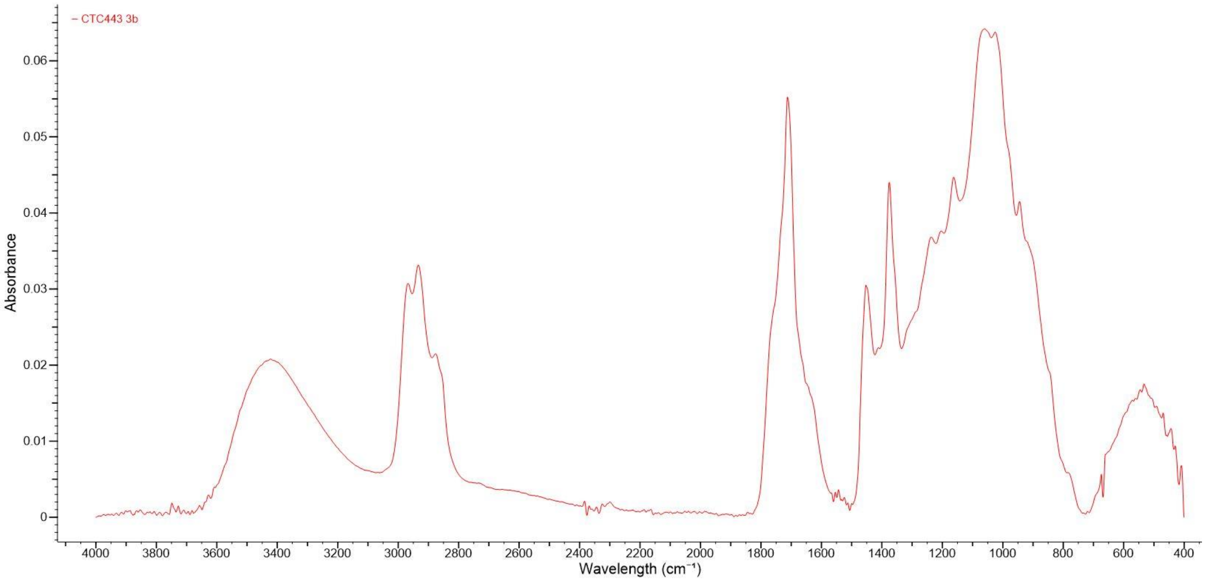
– CTC443 2c
Absorbance
0
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

3a



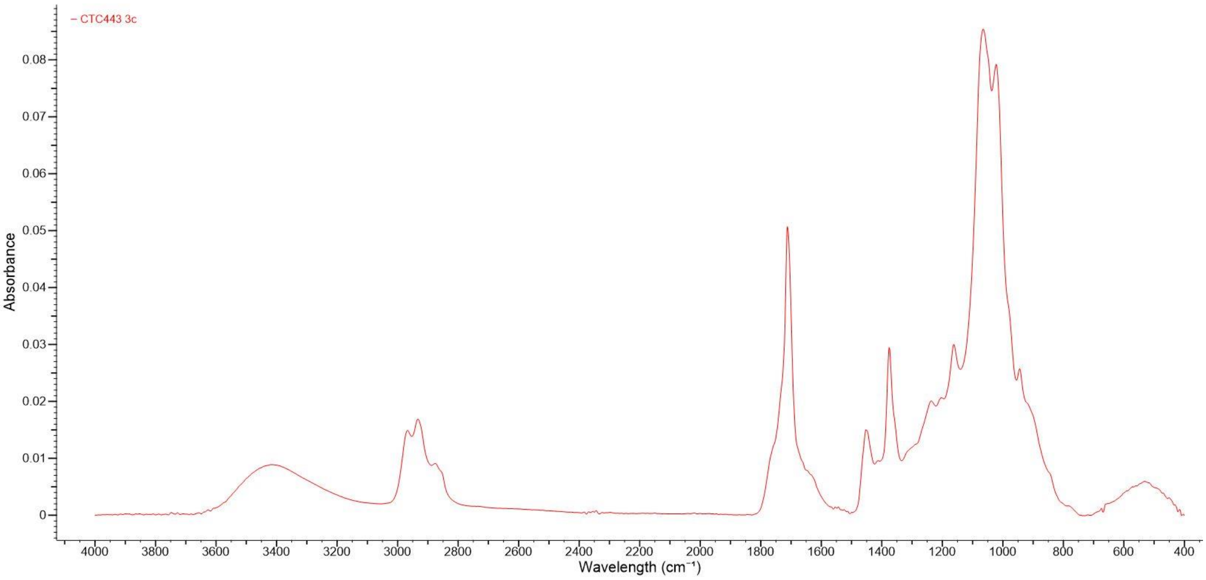
– CTC443 3a
Absorbance
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm^{-1})

3b



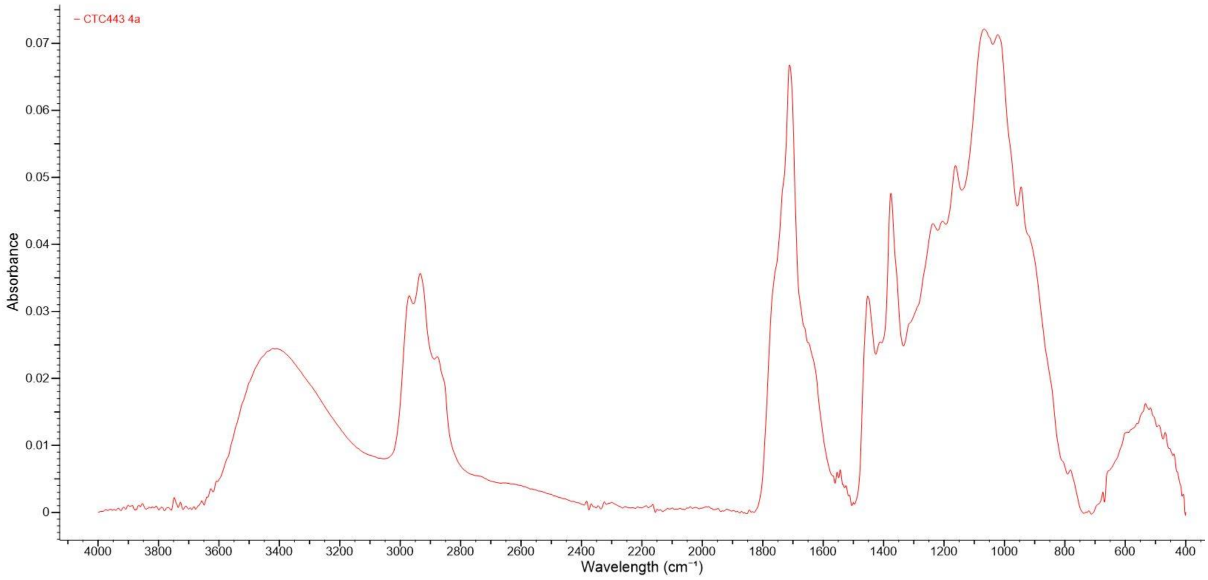
– CTC443 3b
Absorbance
0.06
0.05
0.04
0.03
0.02
0.01
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm^{-1})

3c



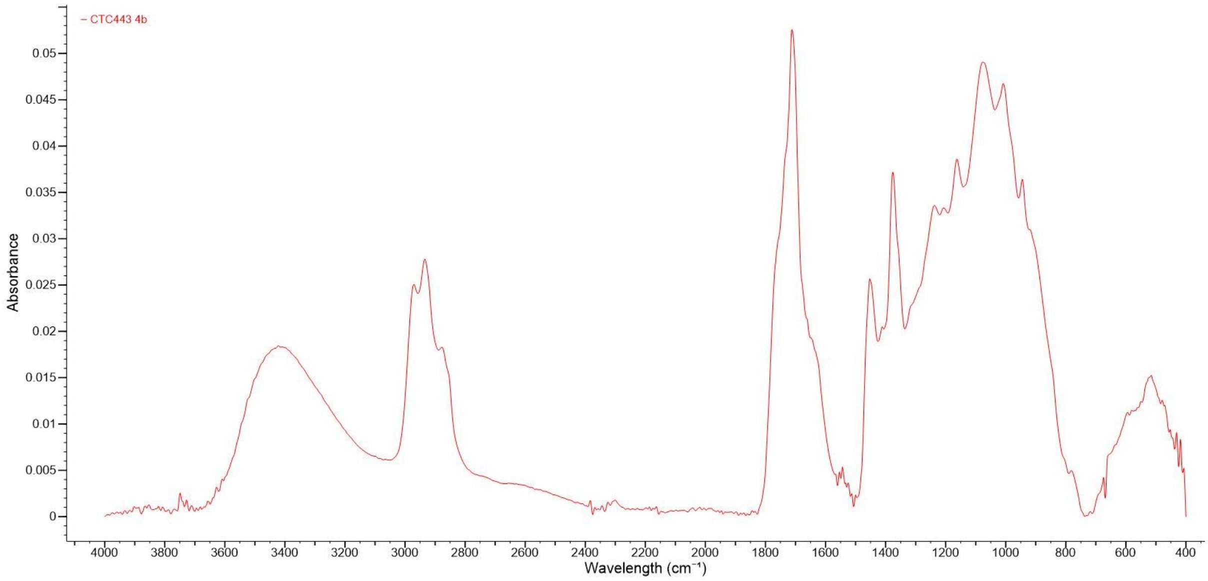
– CTC443 3c
Absorbance
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm^{-1})

4a



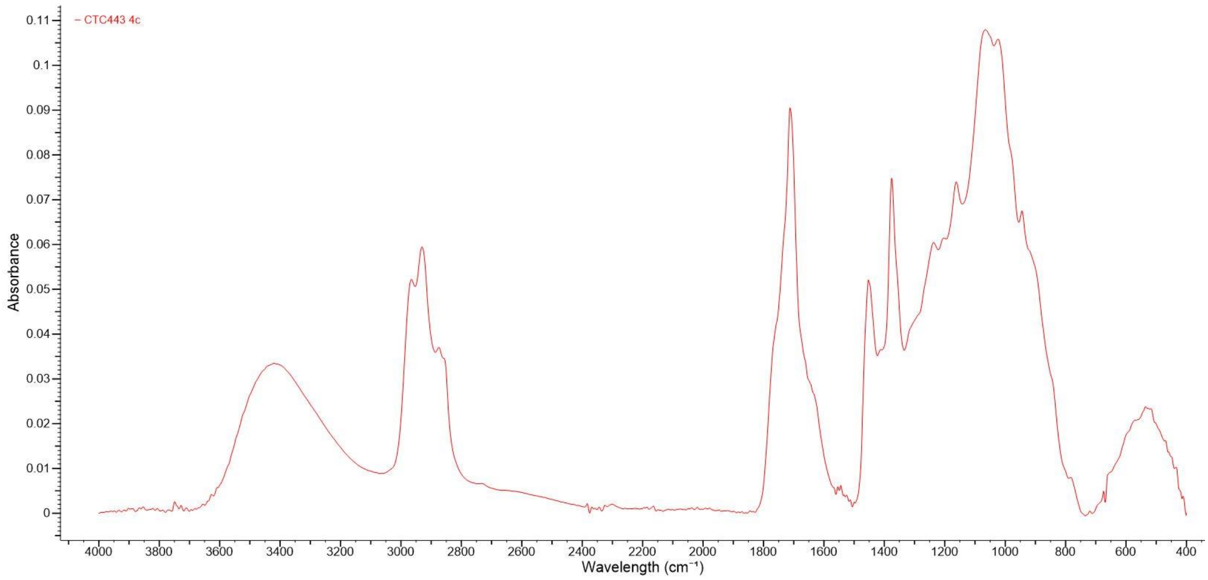
– CTC443 4a
Absorbance
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

4b



– CTC443 4b
Absorbance
0.05
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

4c

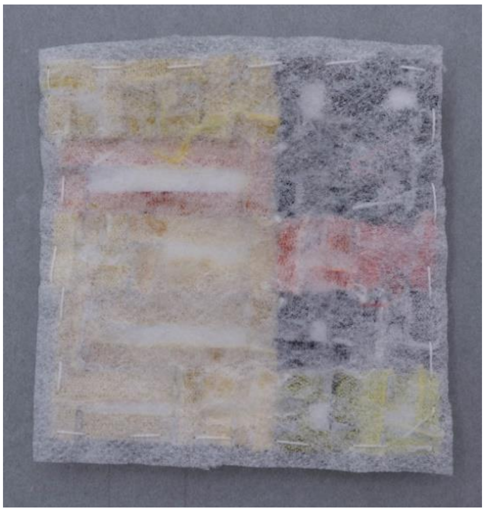
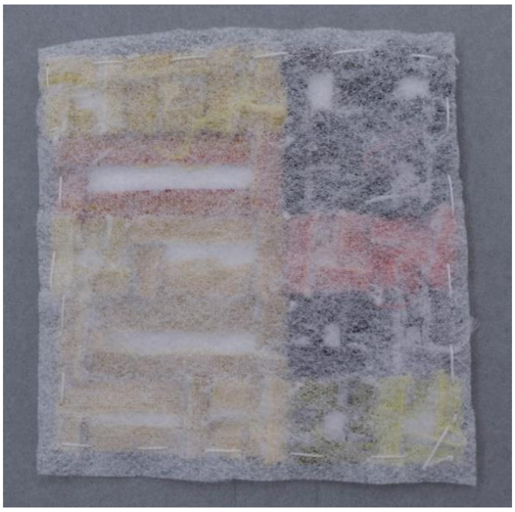


– CTC443 4c
Absorbance
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
4000 3800 3600 3400 3200 3000 2800 2600 2400 2200 2000 1800 1600 1400 1200 1000 800 600 400
Wavelength (cm⁻¹)

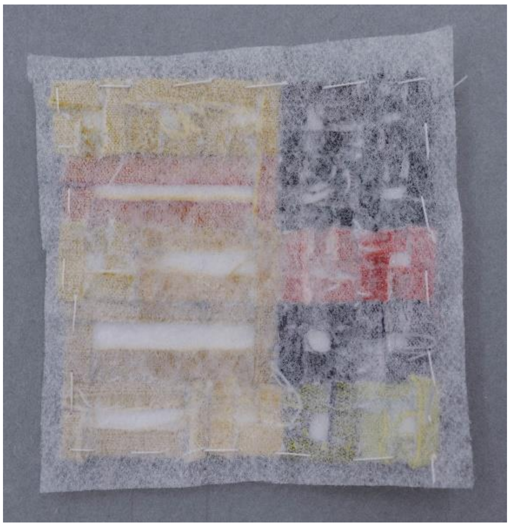
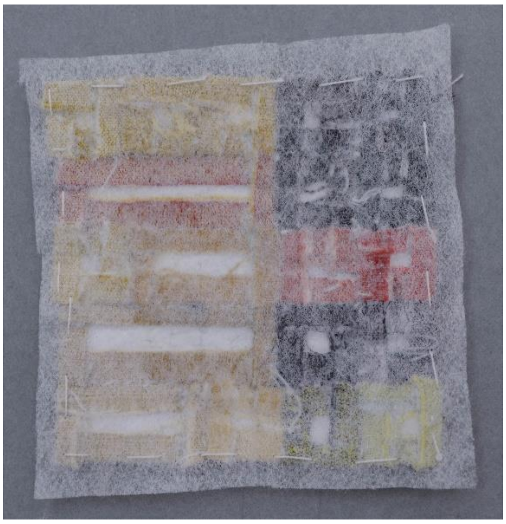
Appendix 10: Images of results from main testing

Left image before treatment and right image after treatment.

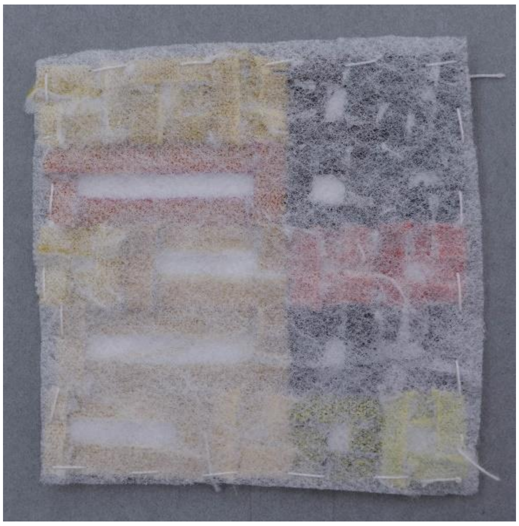
1a

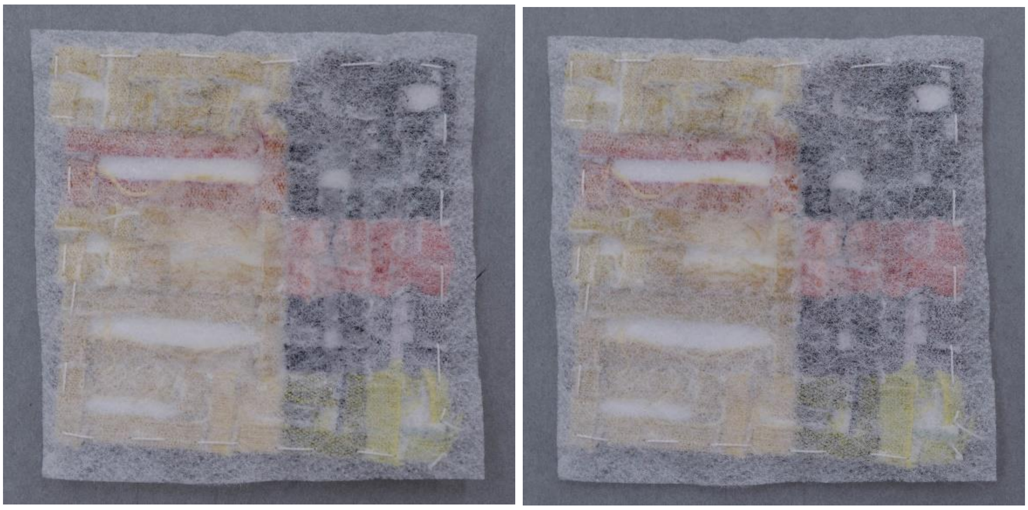
1b

1c

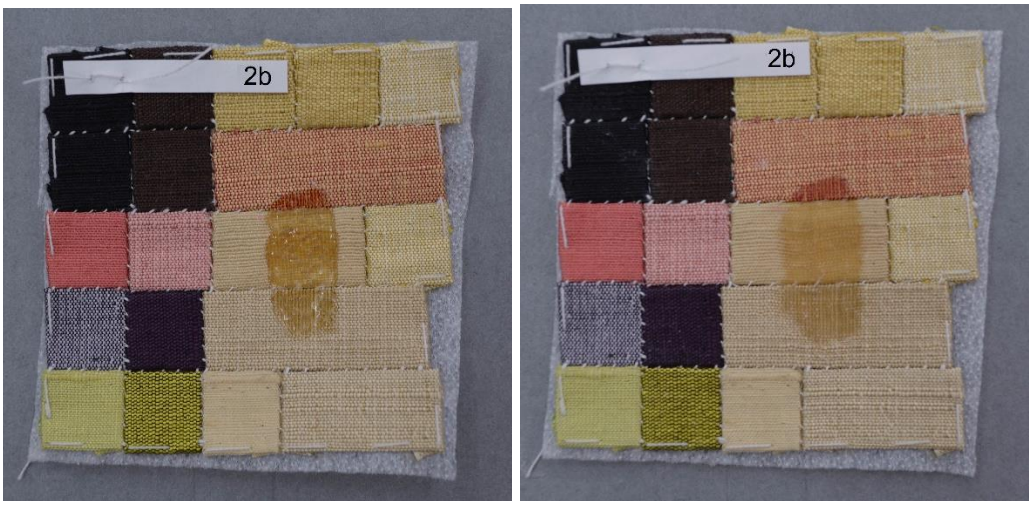



1d



2a

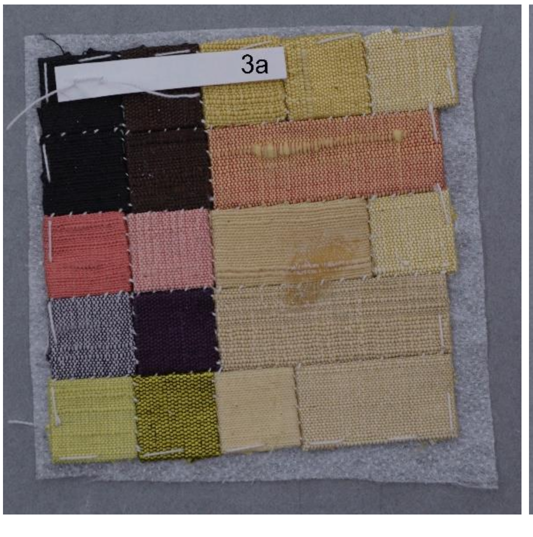
2b



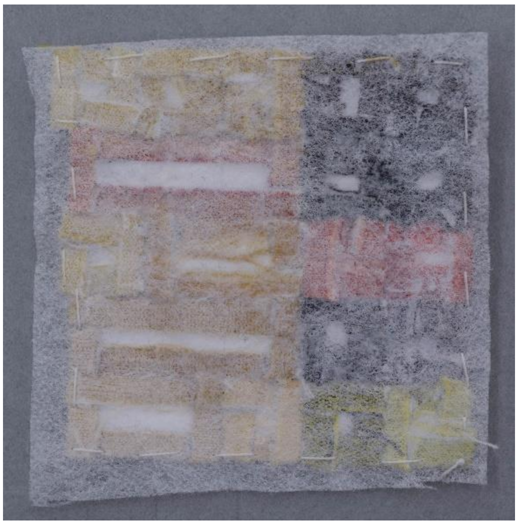
2c

2d

3a Front

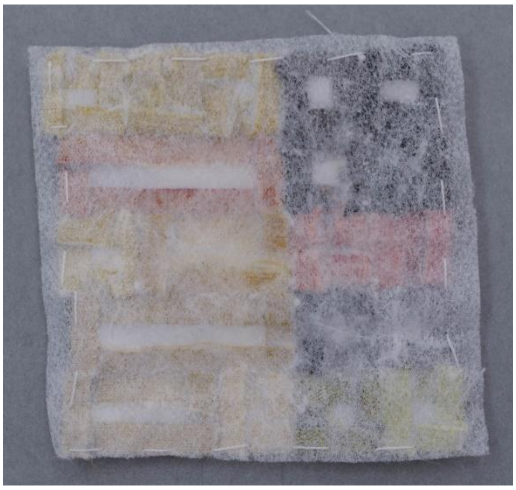
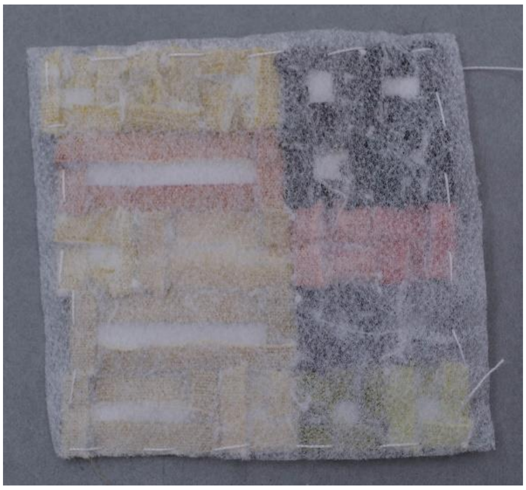


3a Back

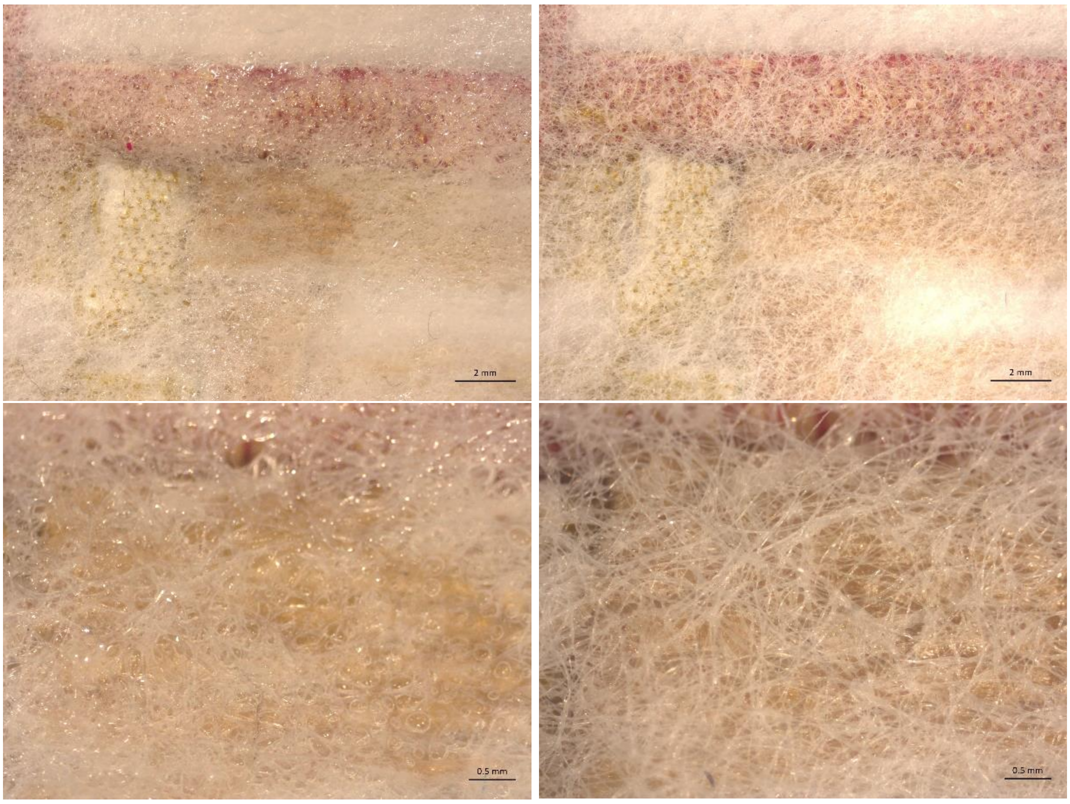
3b Front

3b Back

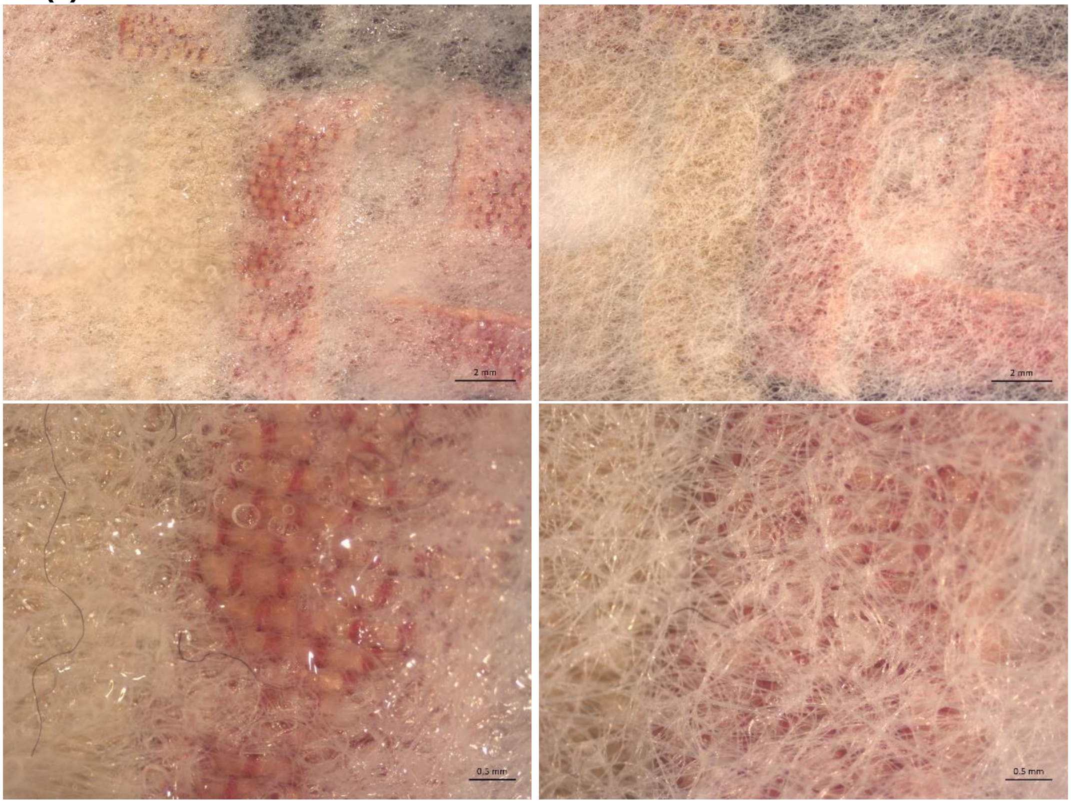



Photographs under Magnification (taken with stereomicroscope)

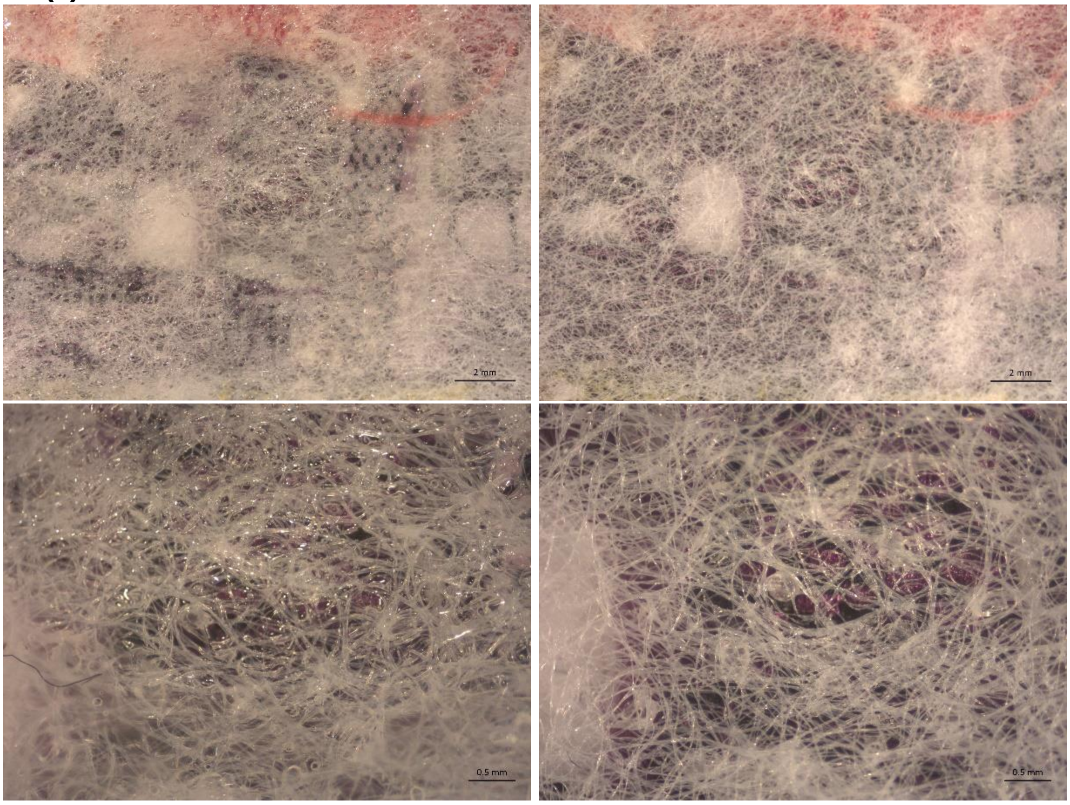
1a (1)



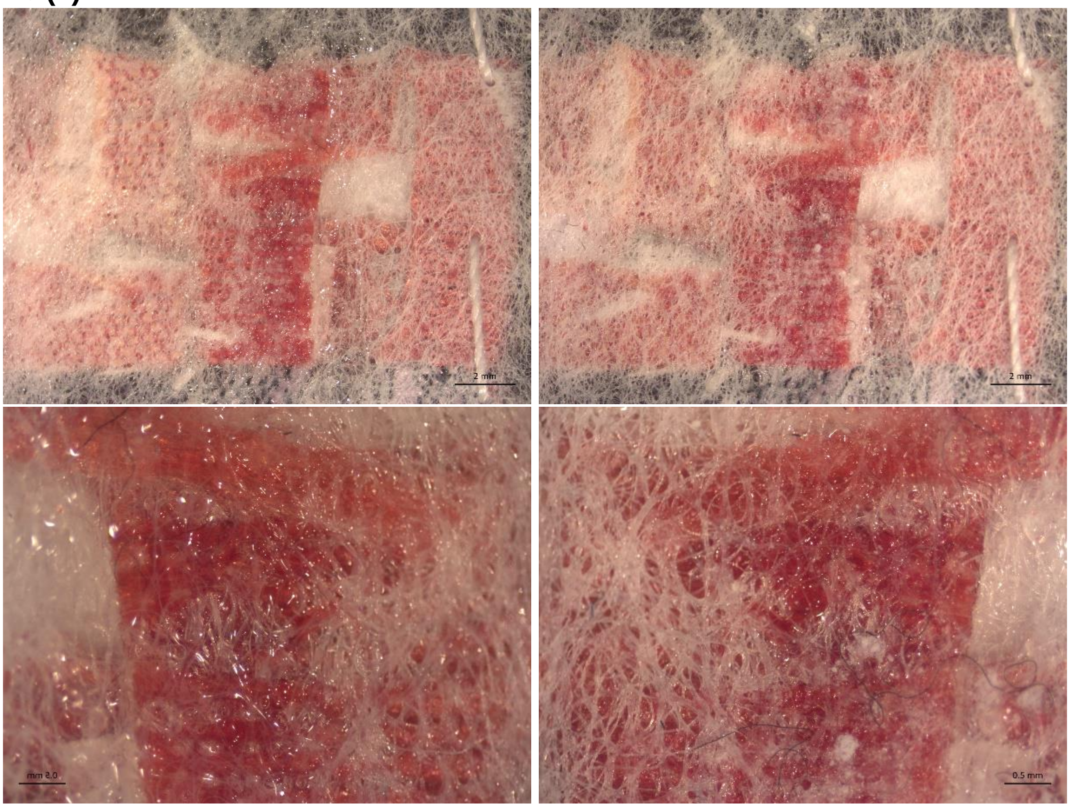
1a (2)



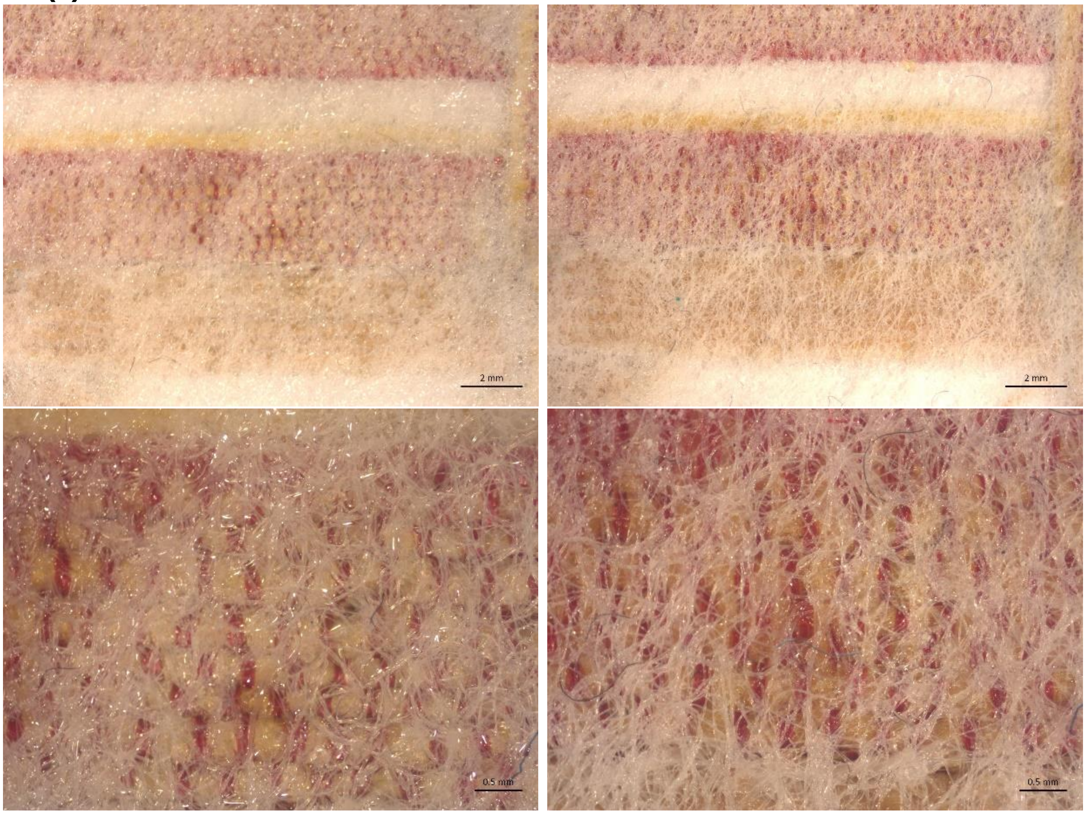
1a (3)



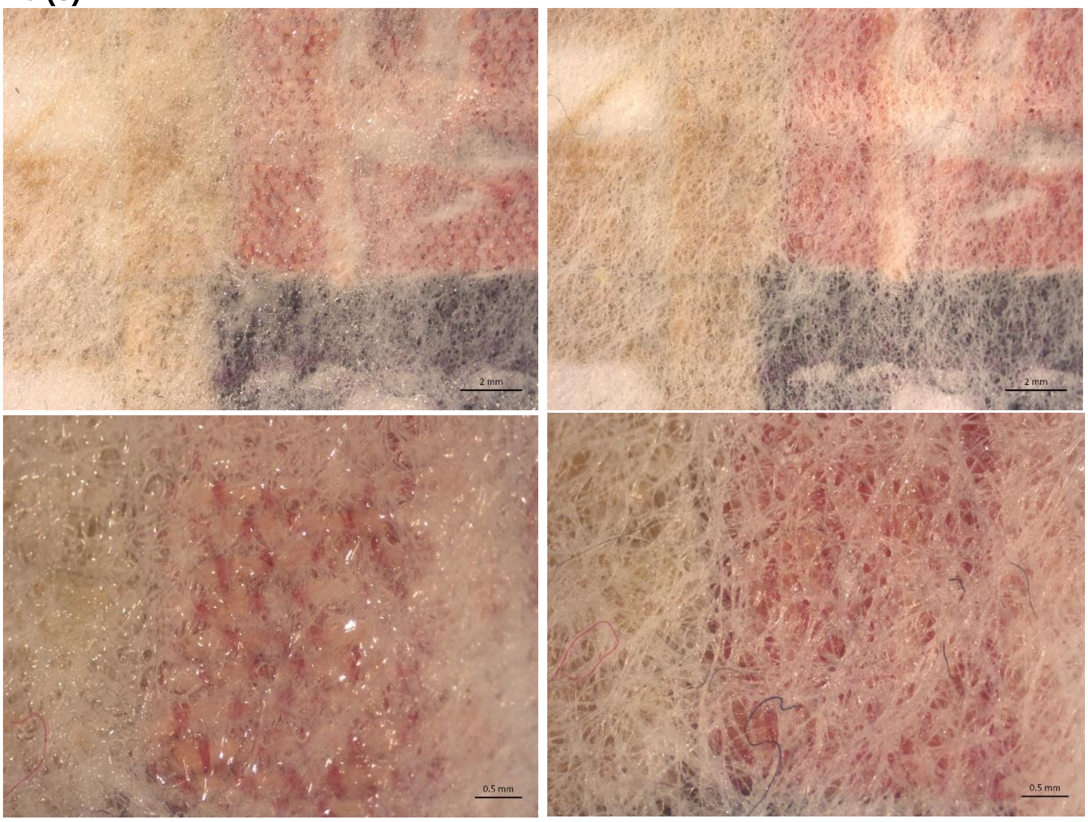
1b (1)



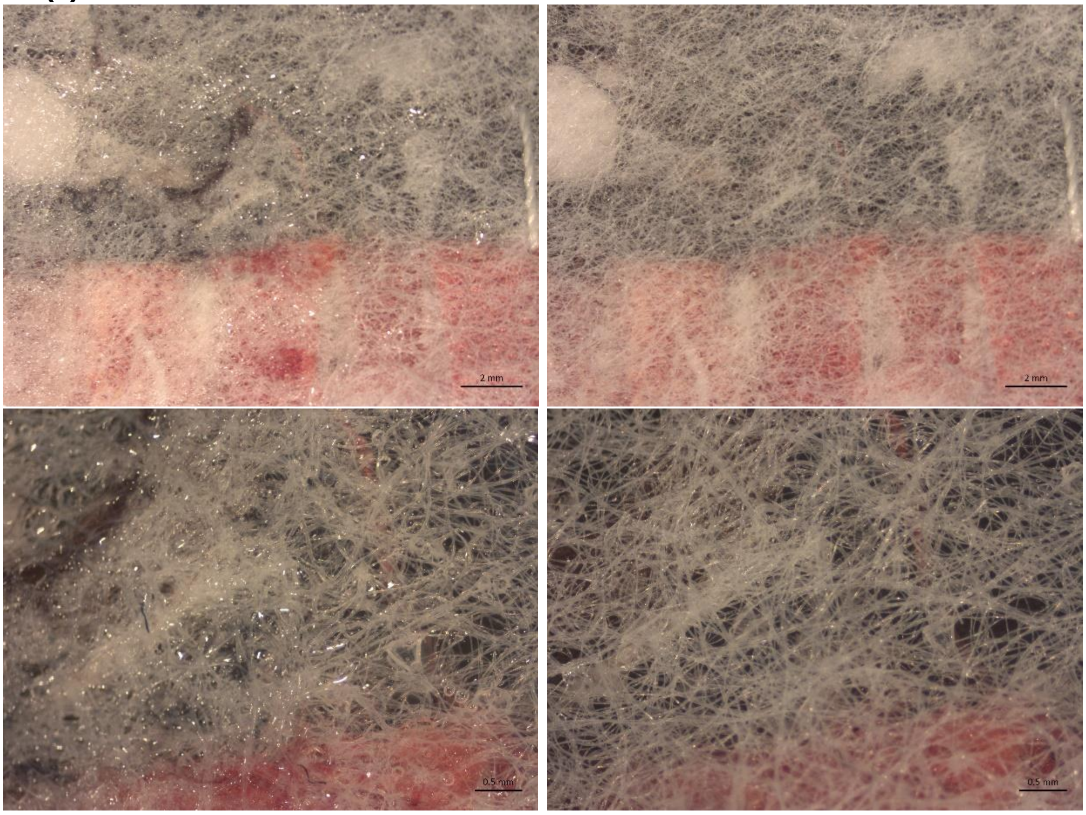
1b (2)



1b (3)

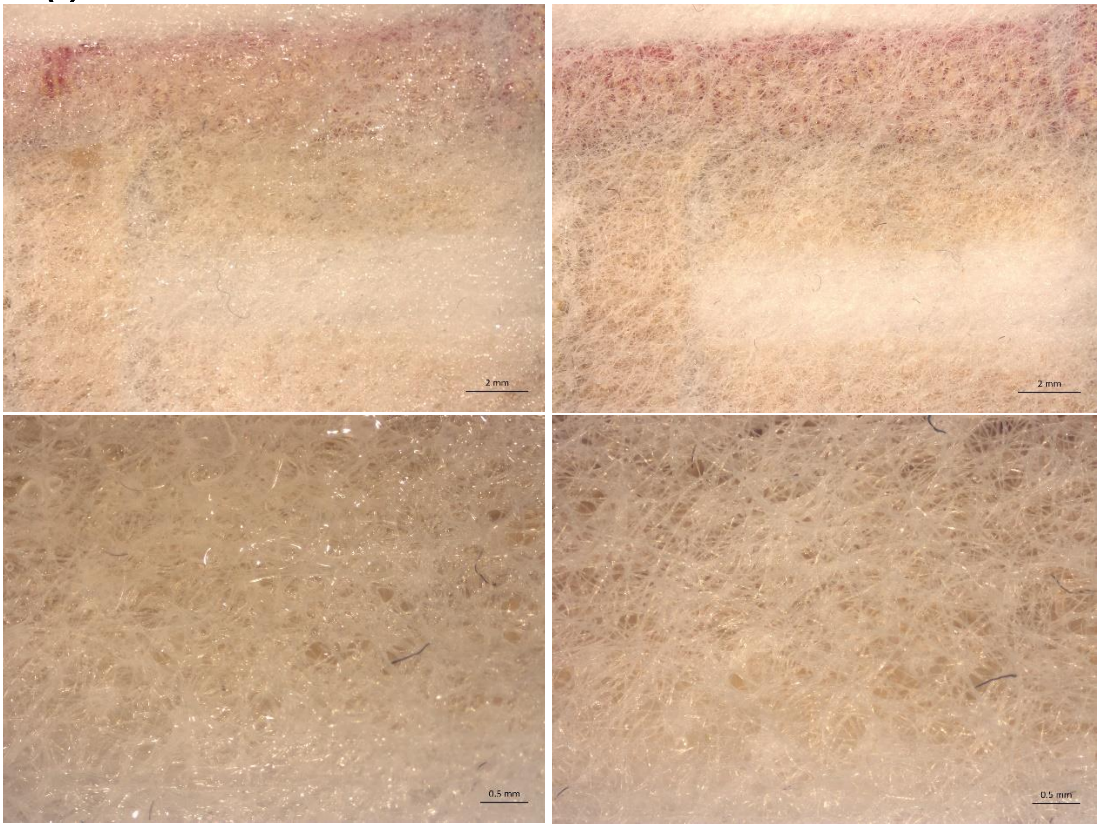


1c (1)

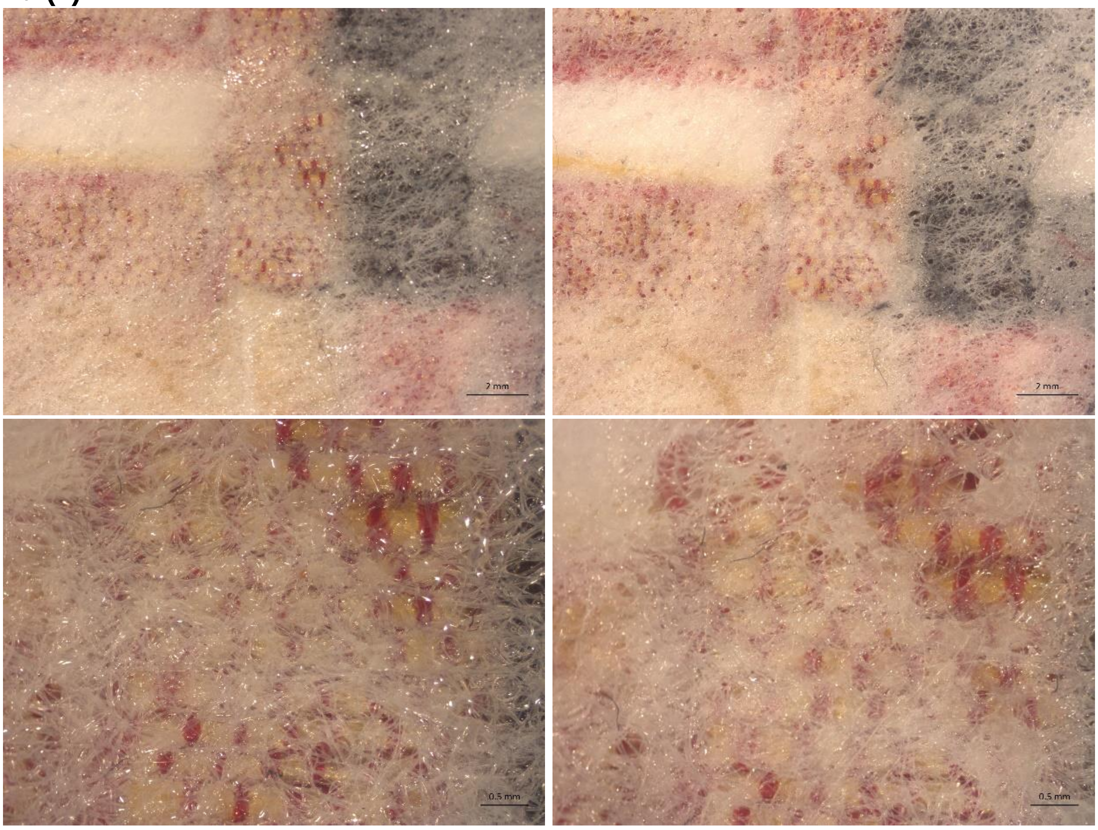


1c (2)

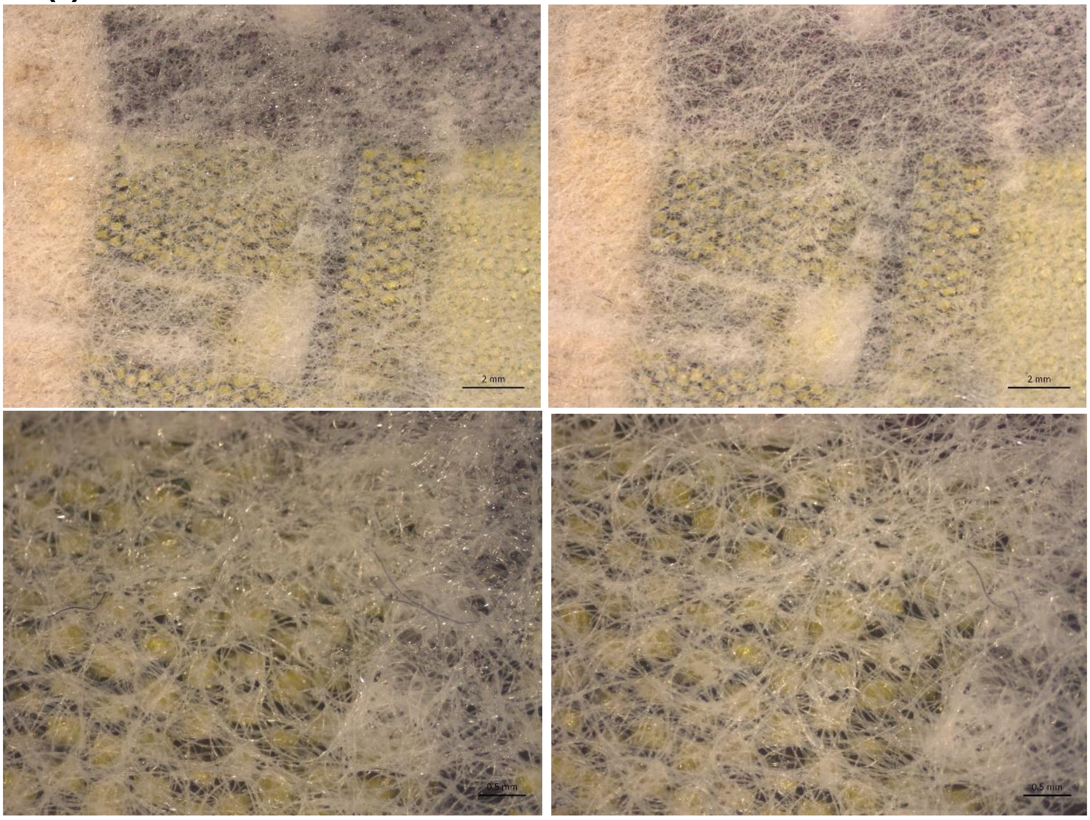
1c (3)



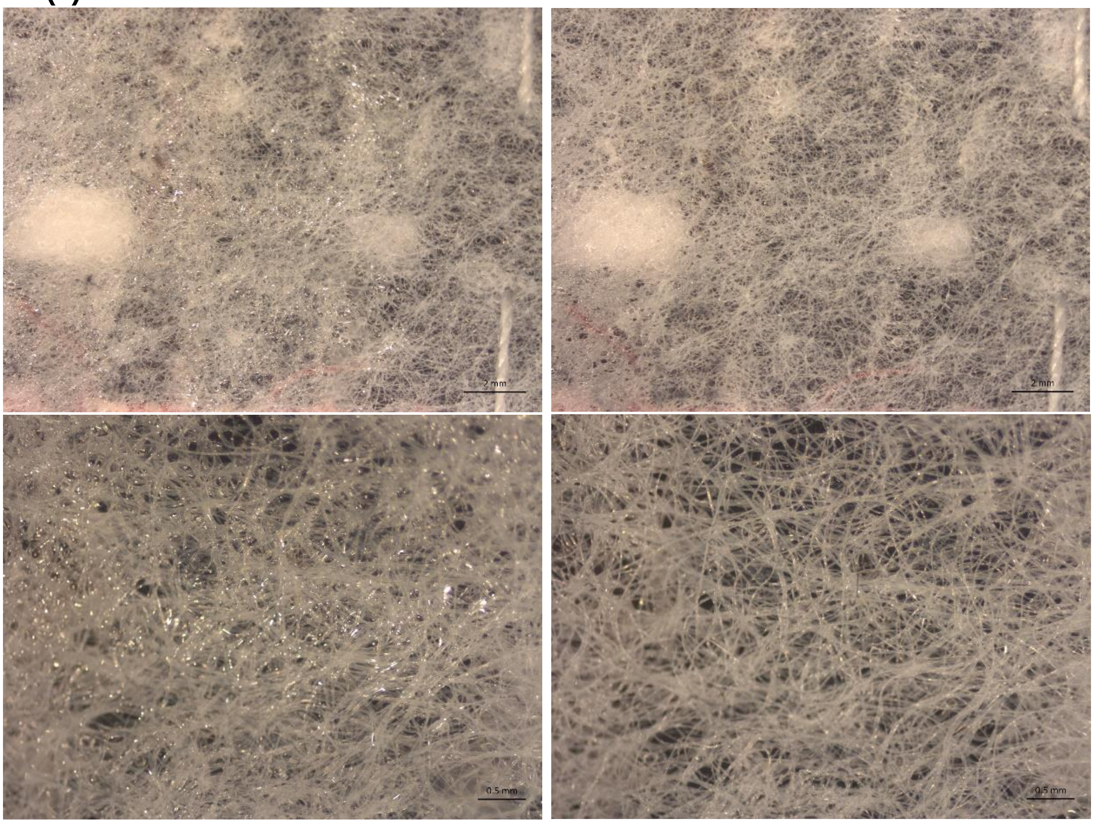
1d (1)



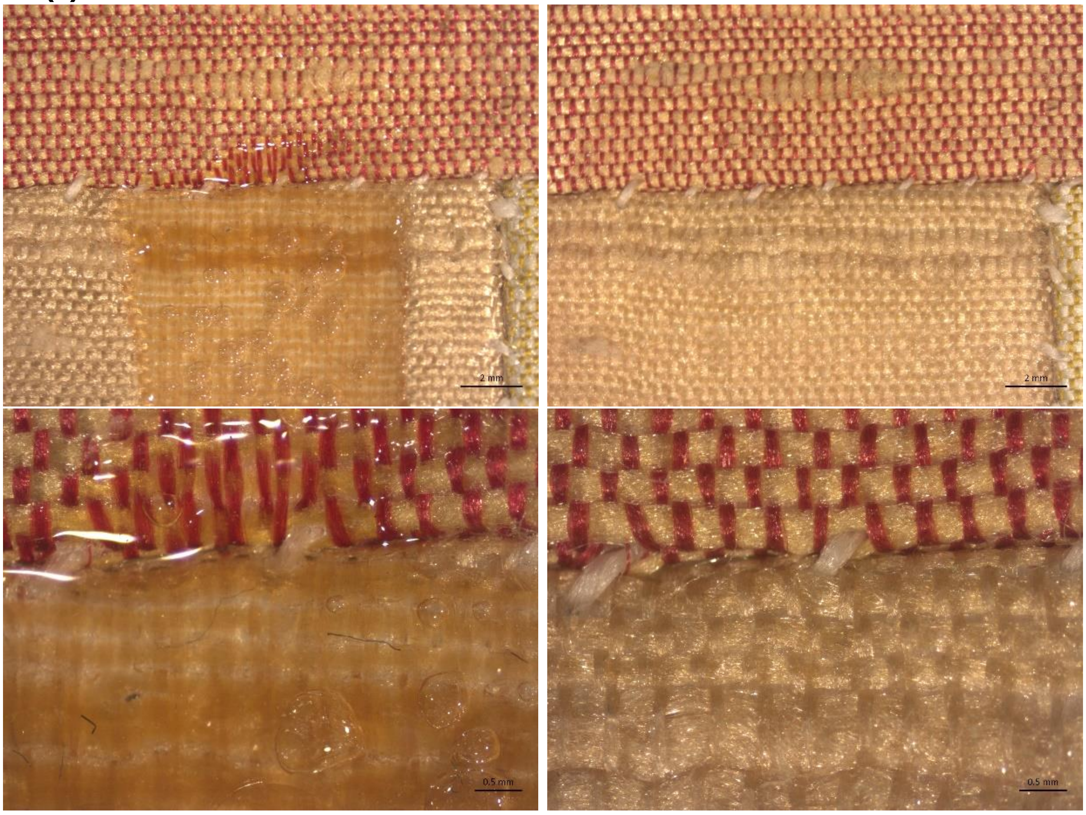
1d (2)



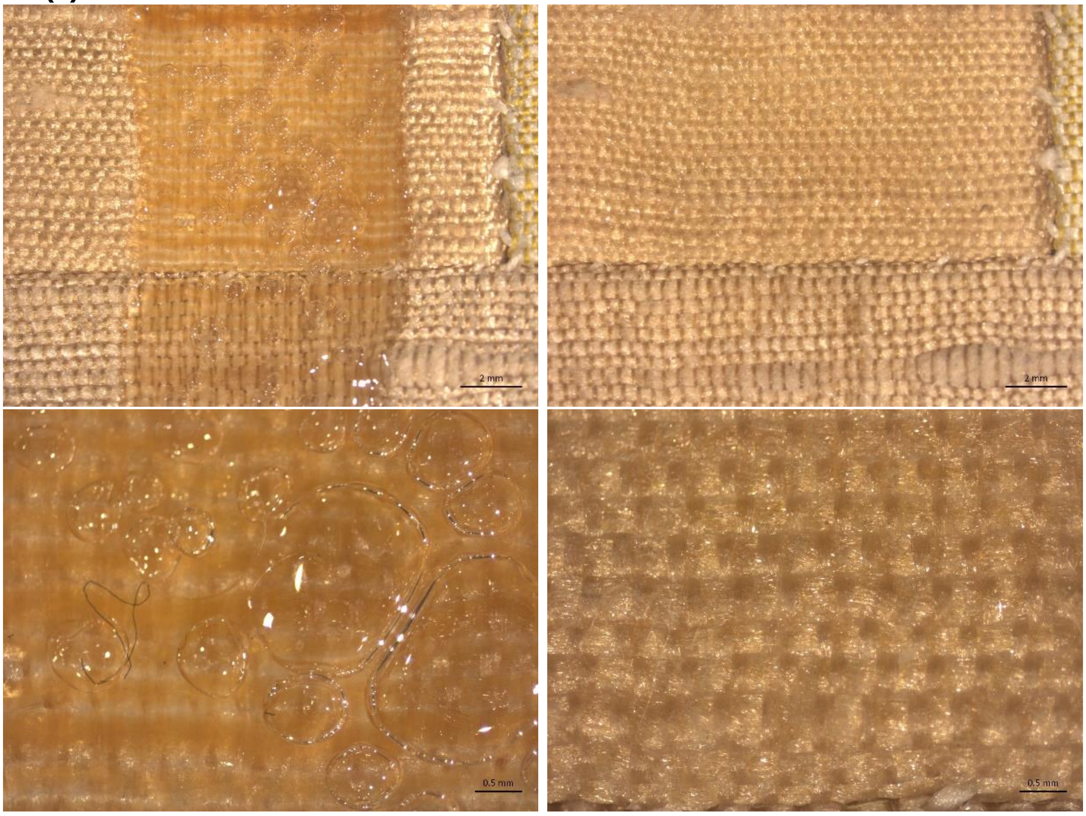
1d (3)



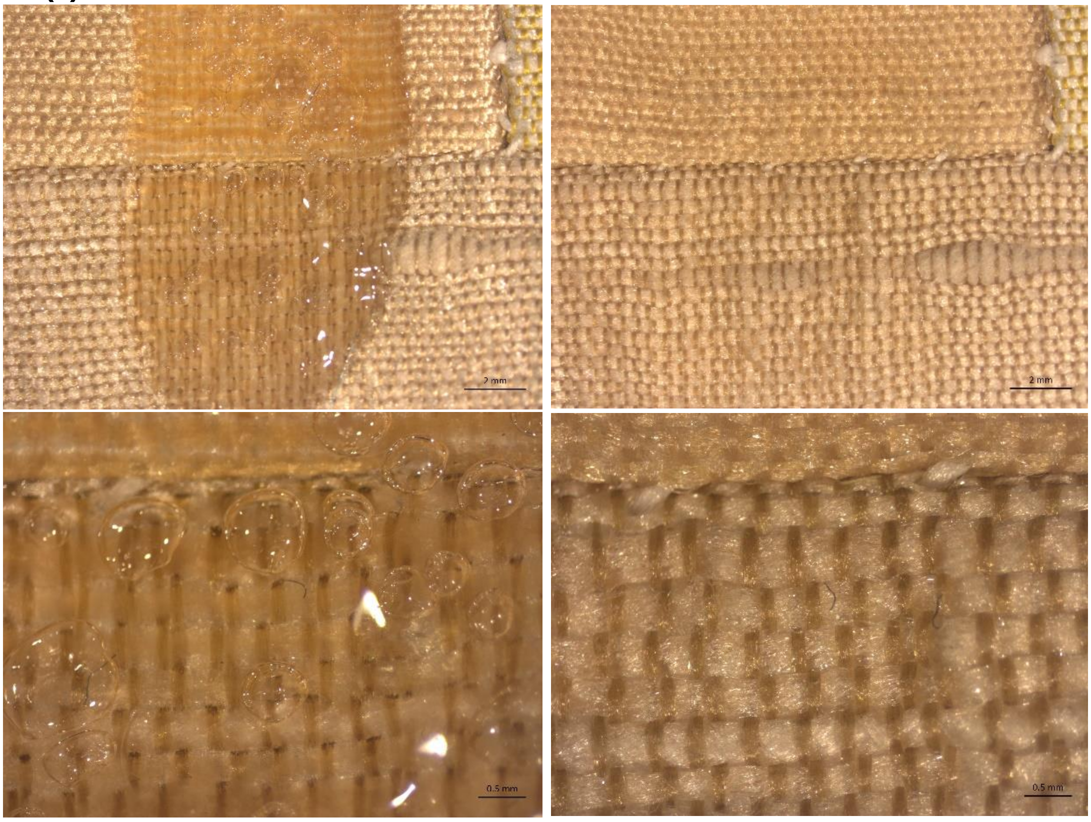
2a (1)



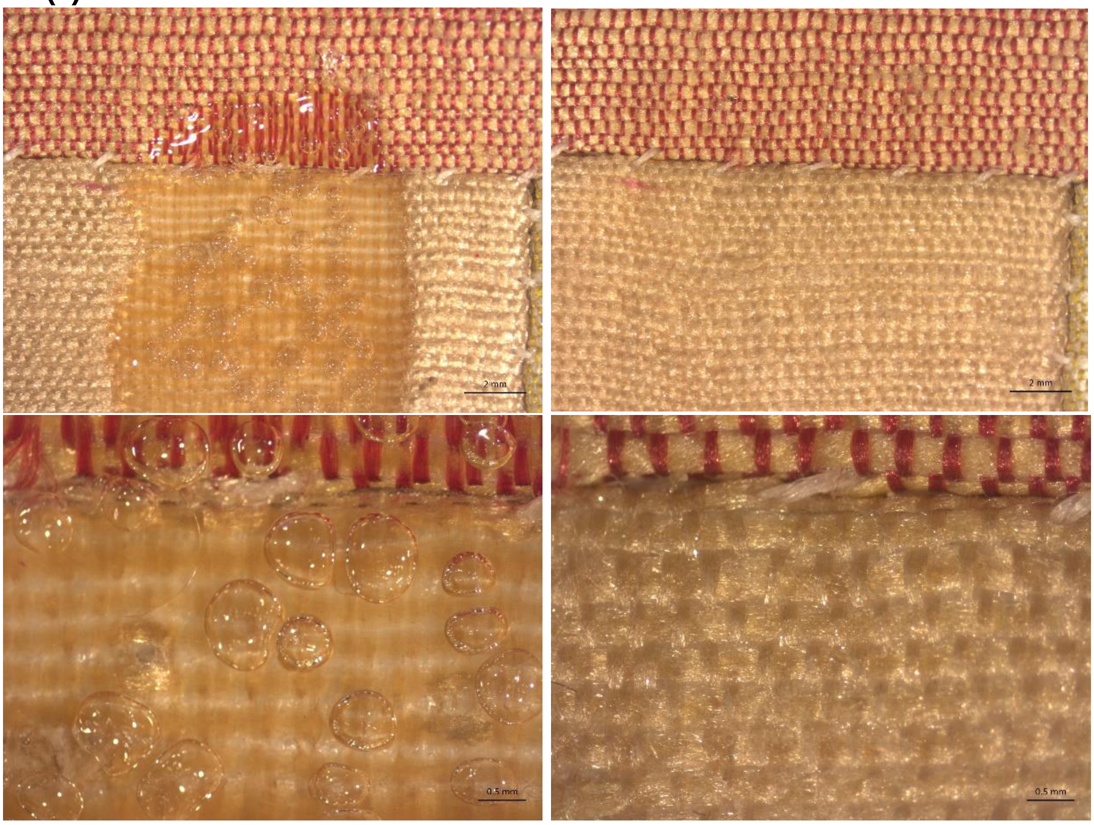
2a (2)



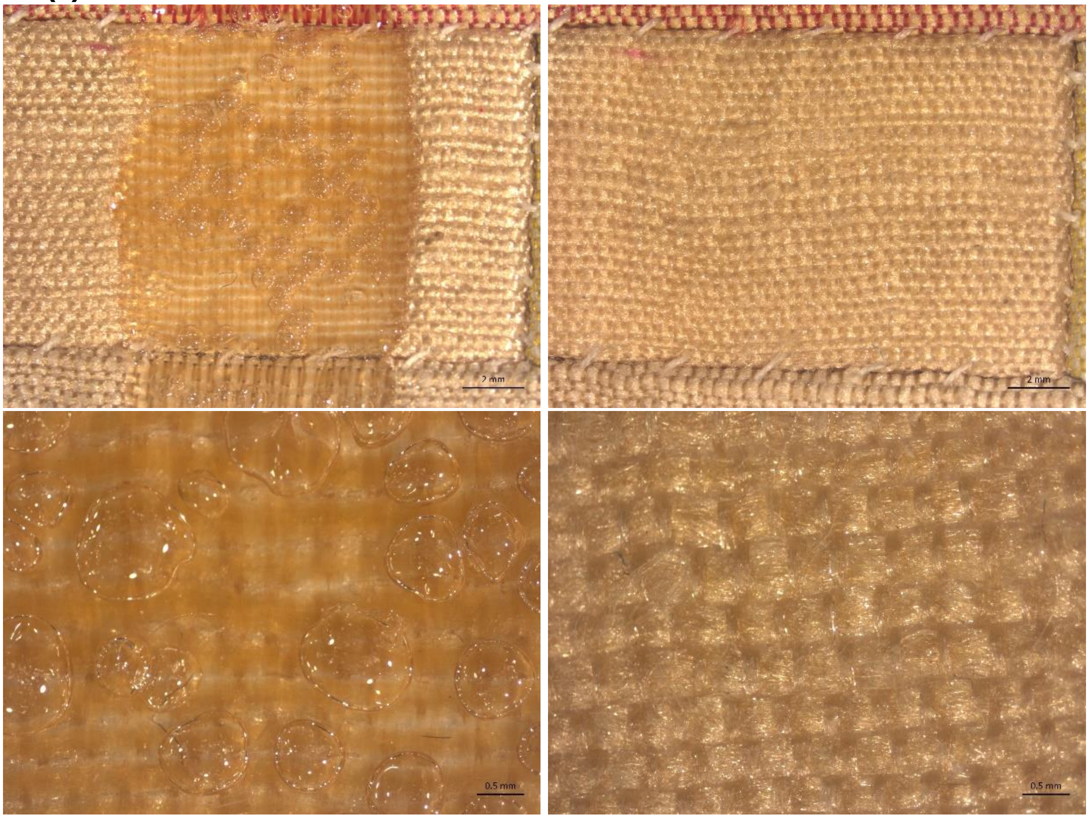
2a (3)



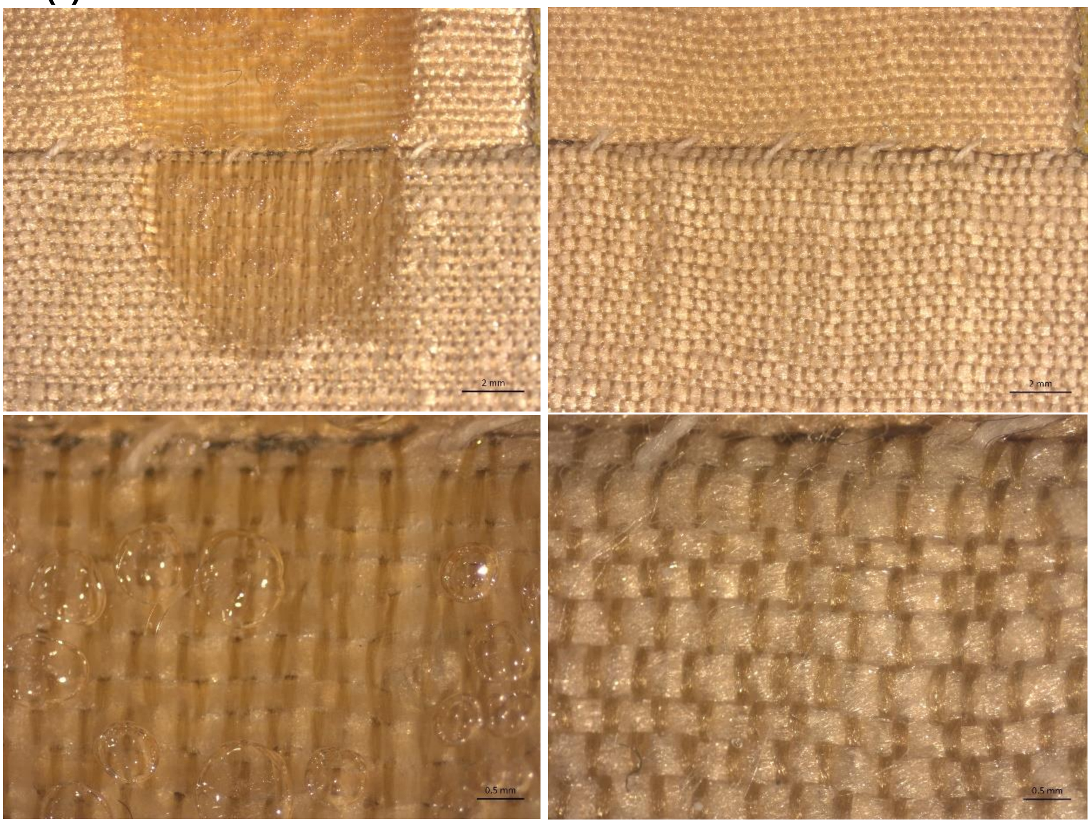
2b (1)



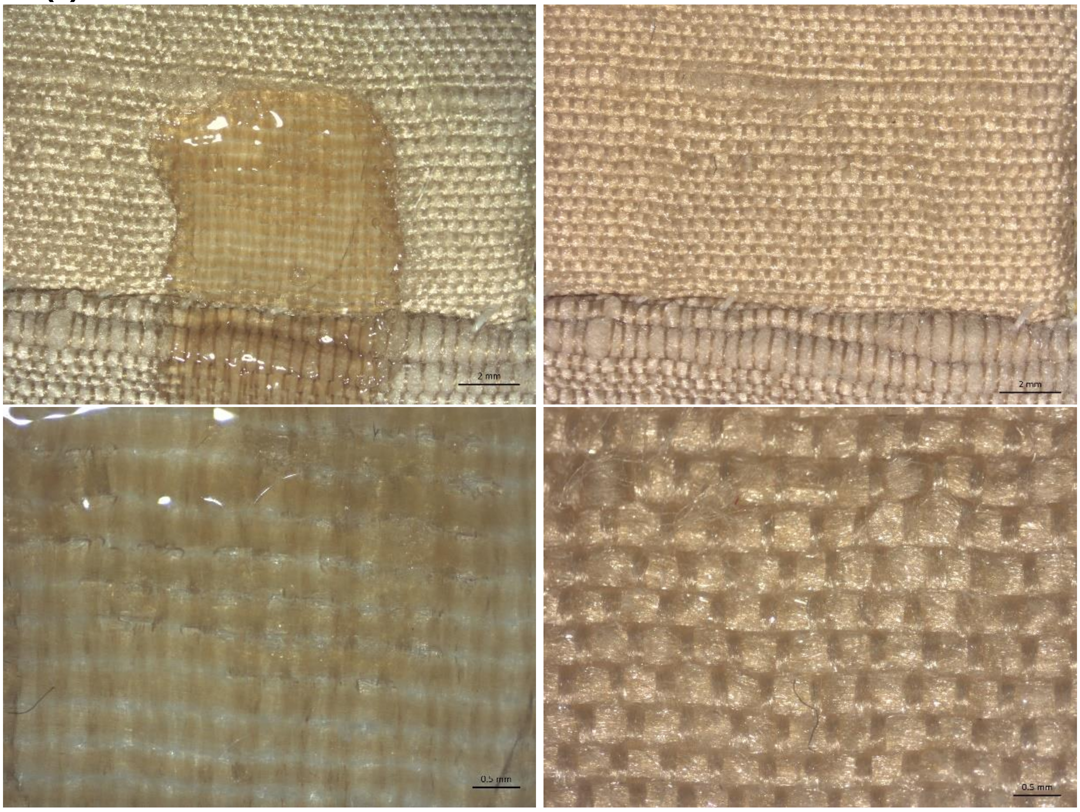
2b (2)



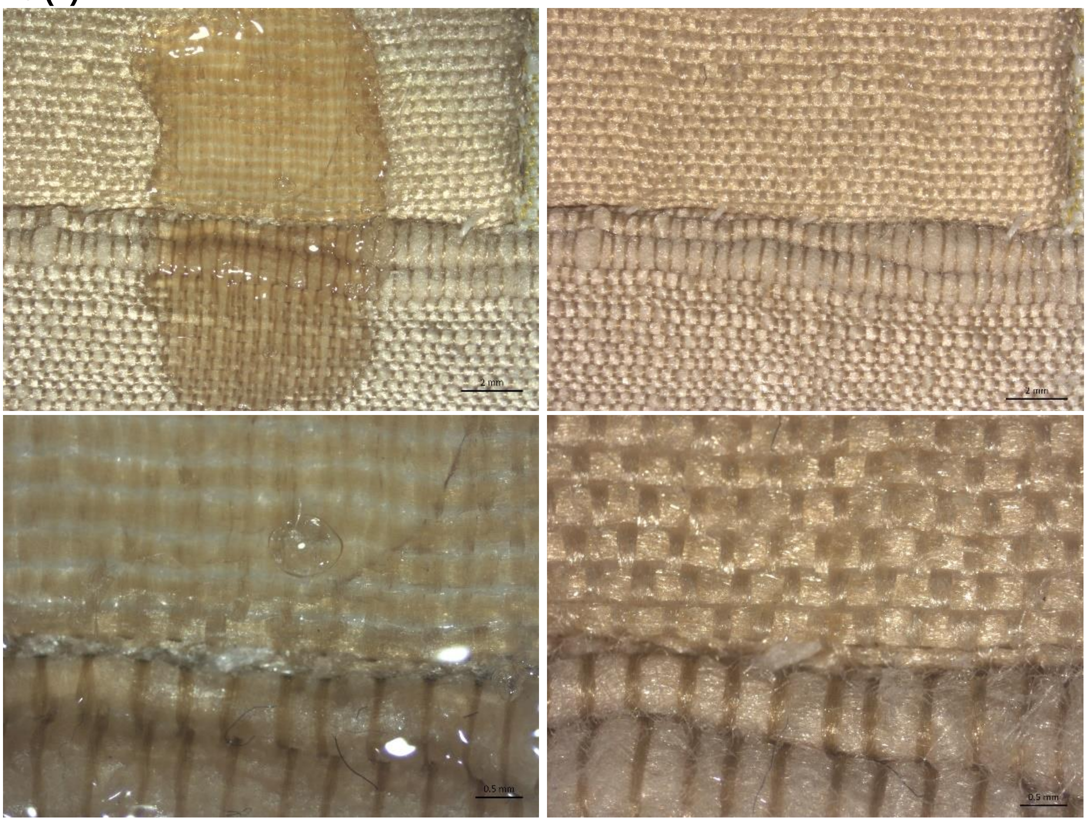
2b (3)



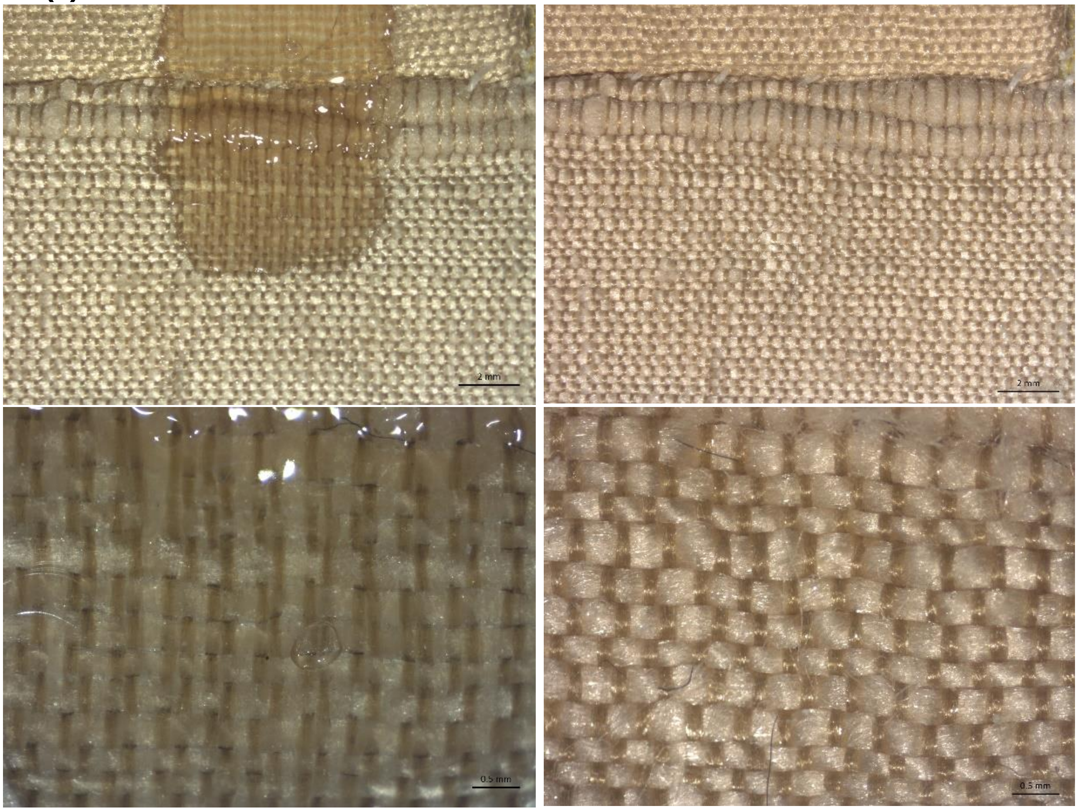
2c (1)



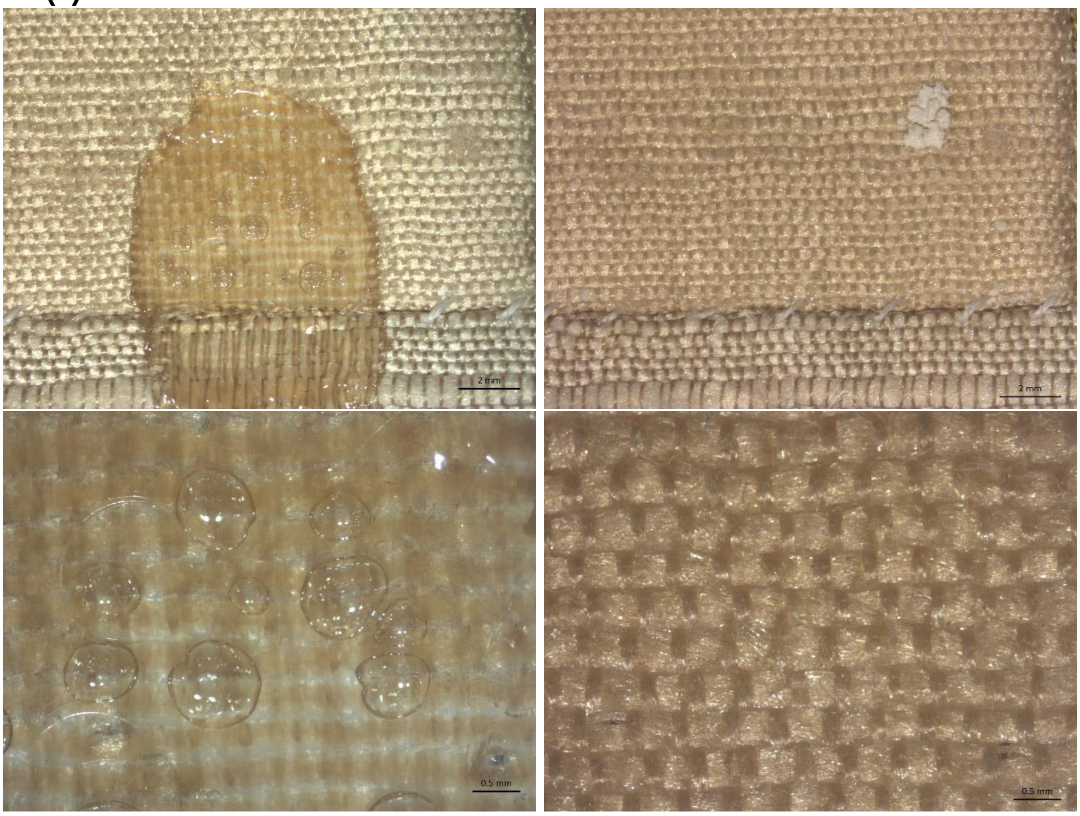
2c (2)



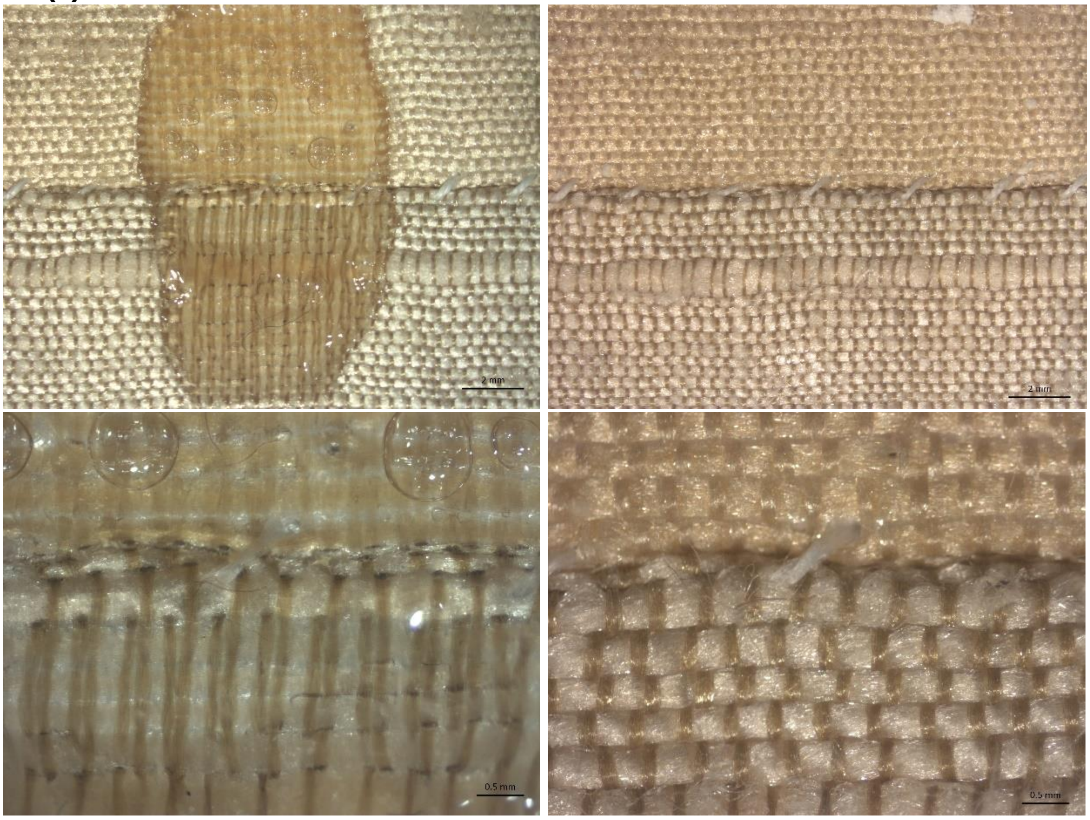
2c (3)



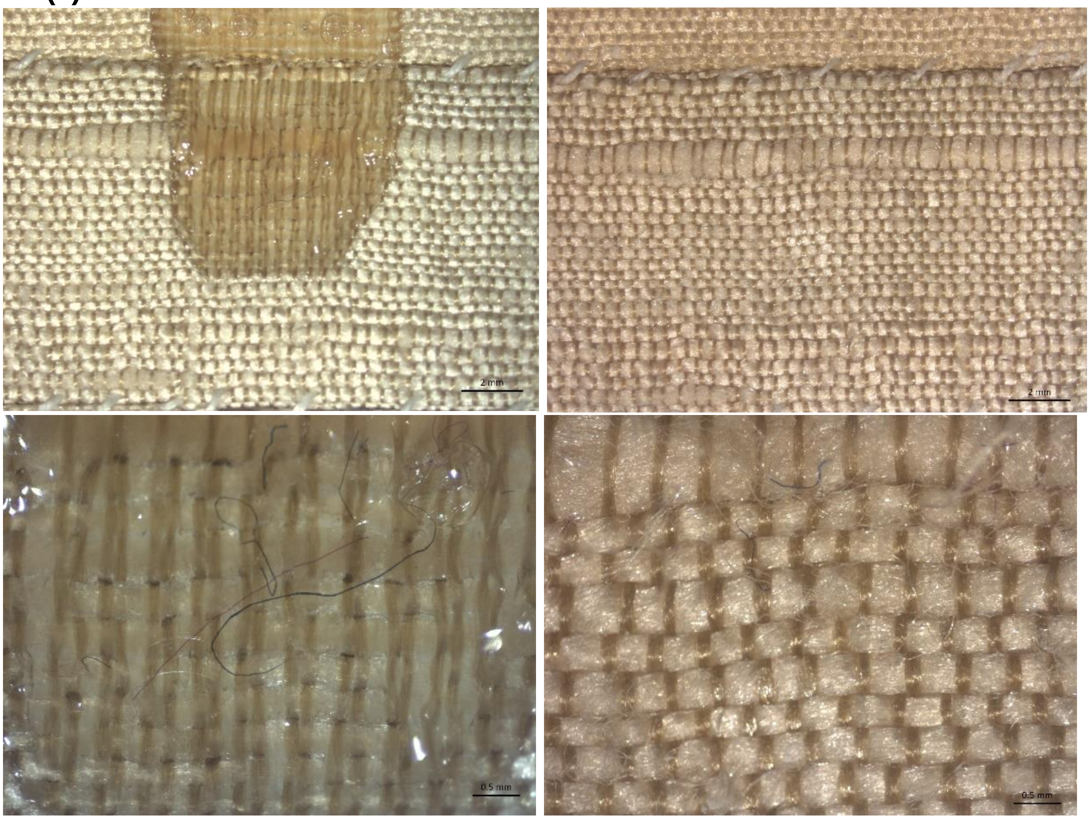
2d (1)



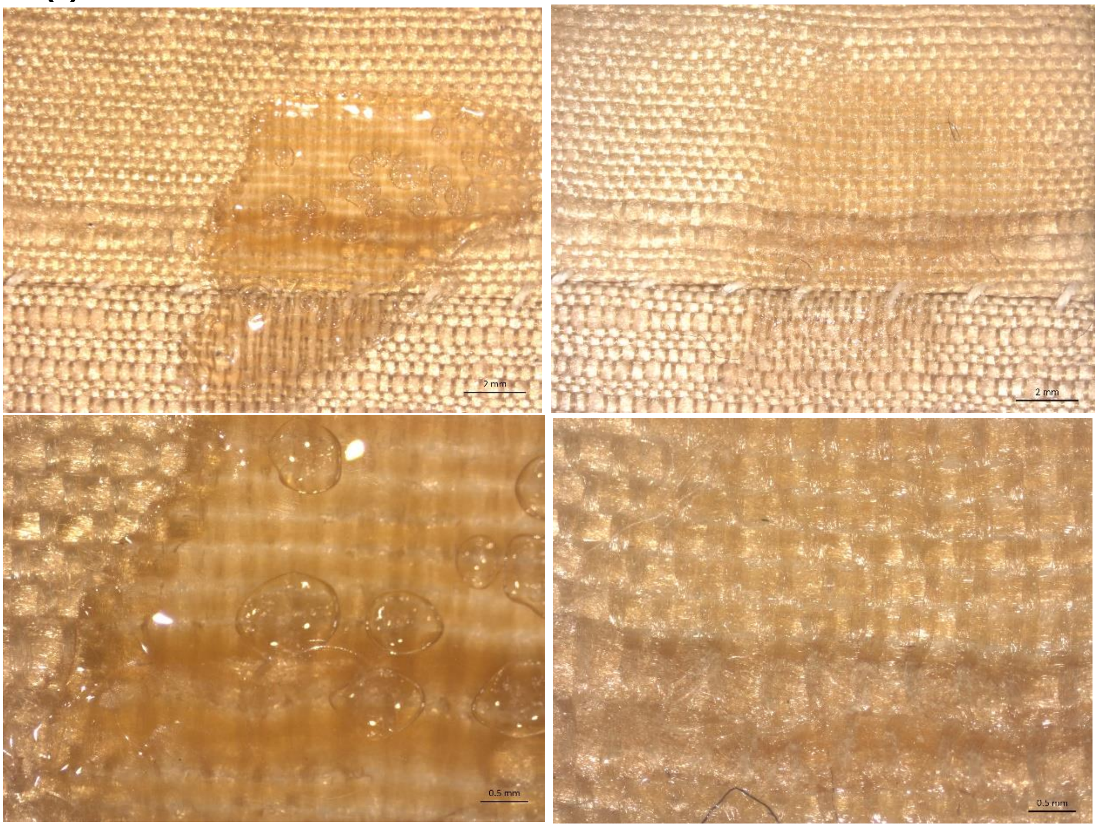
2d (2)



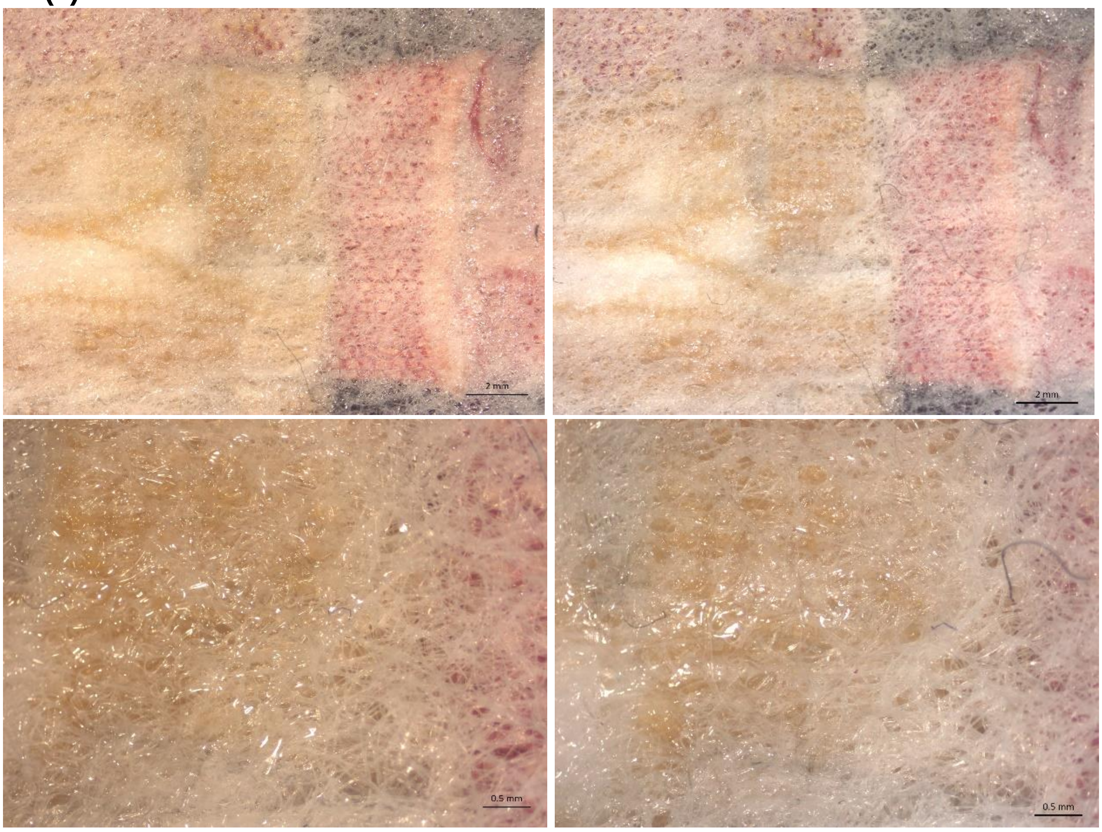
2d (3)



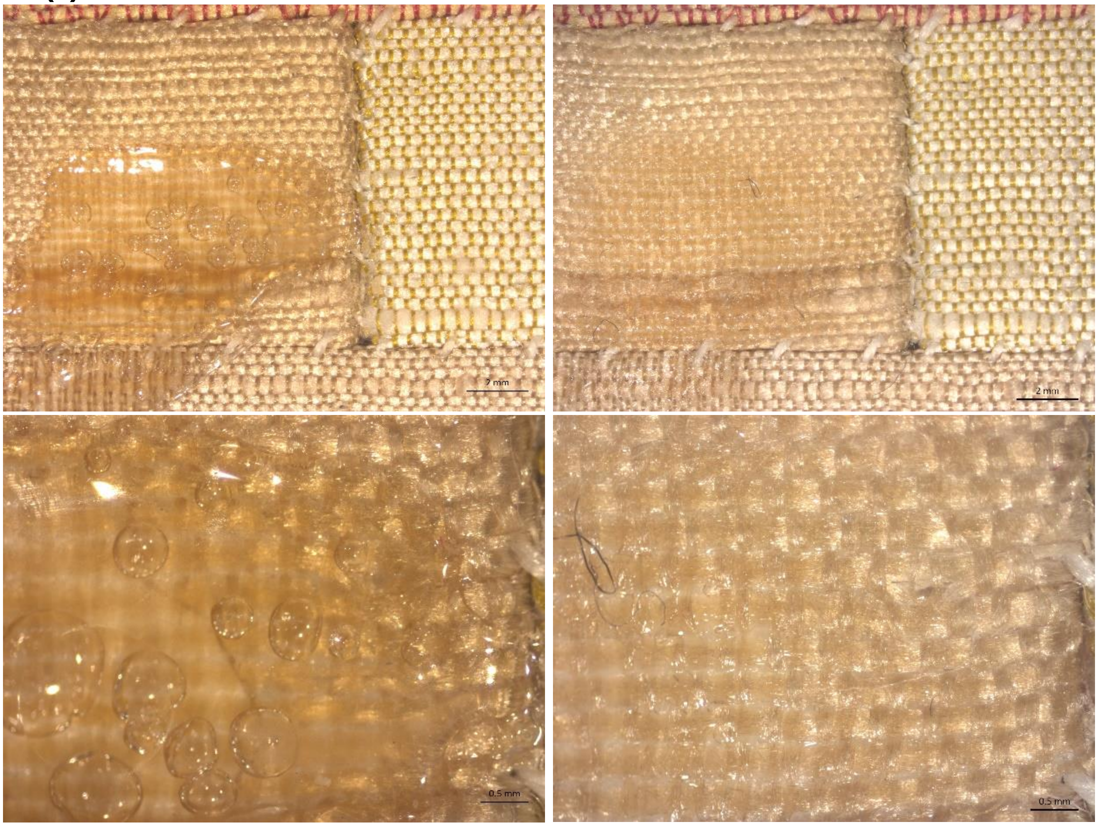
3a (1) Front



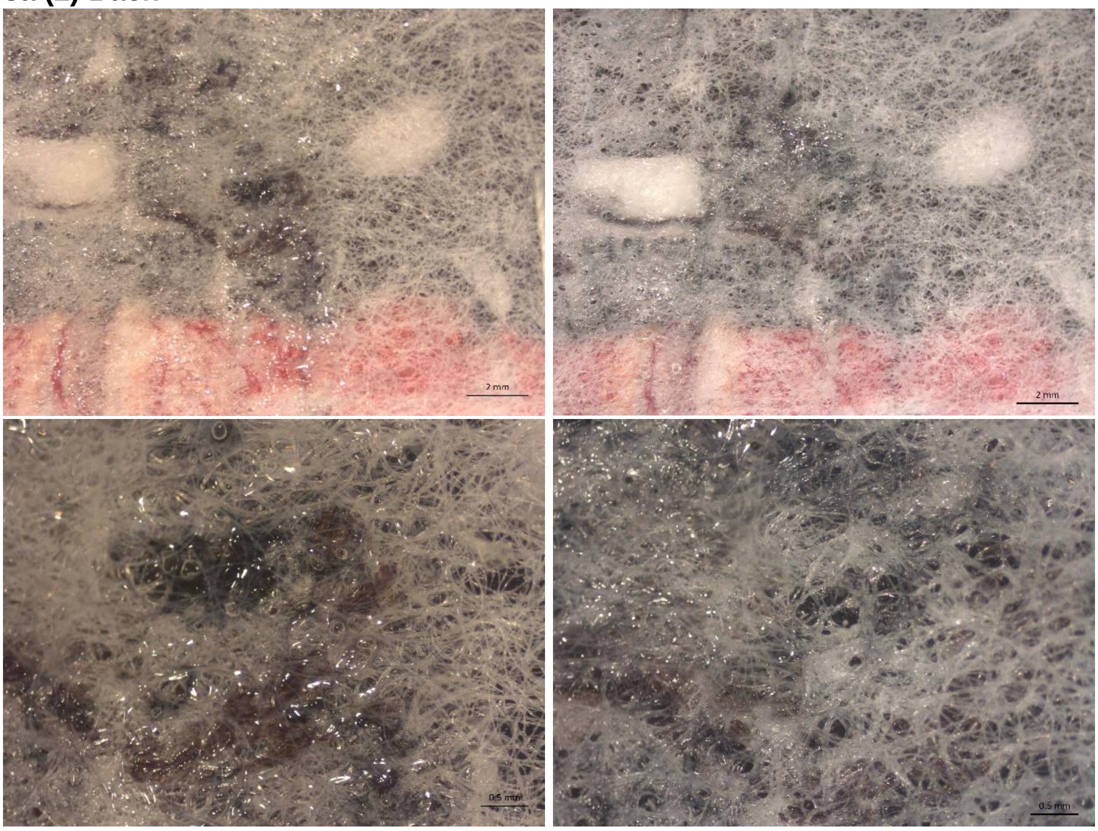
3a (1) Back



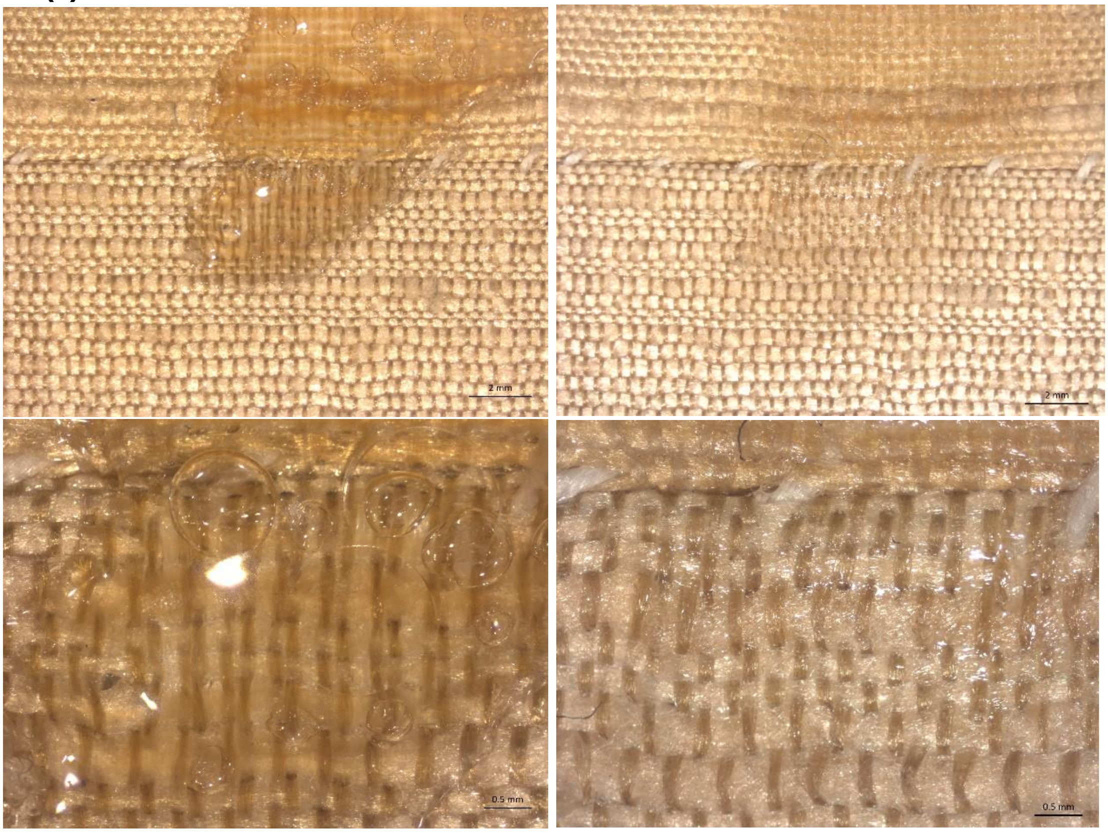
3a (2) Front



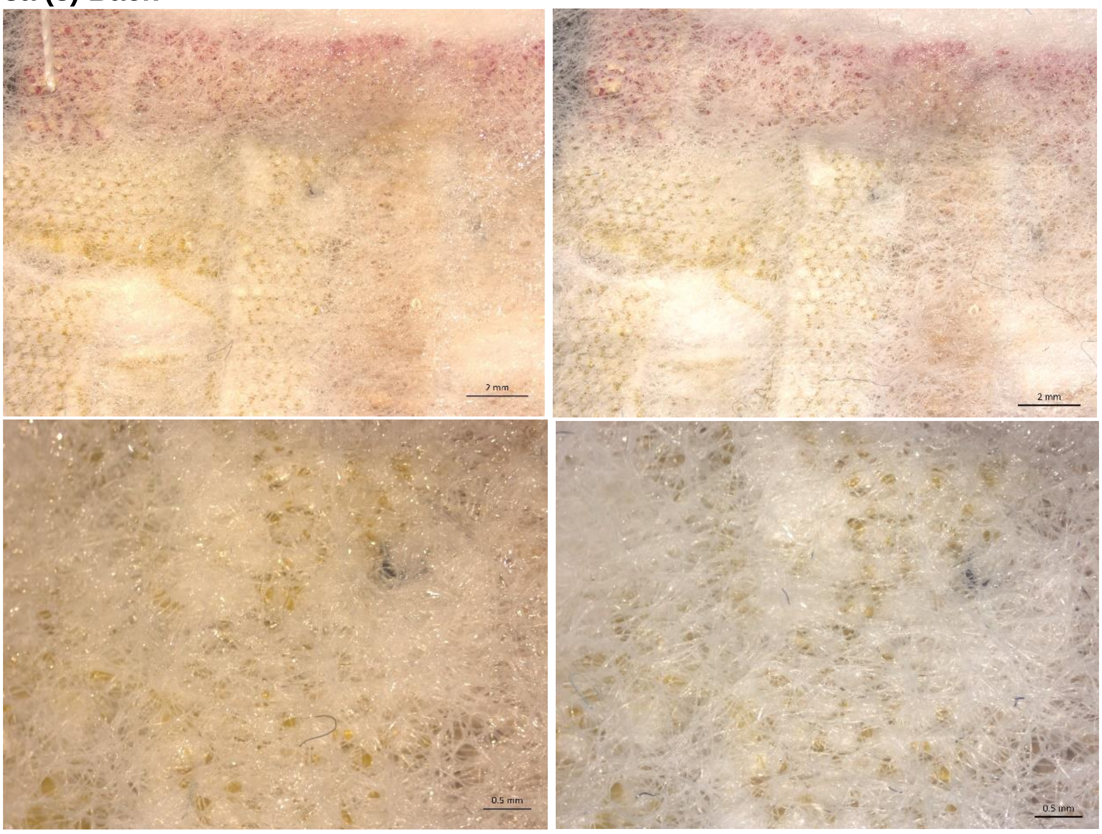
3a (2) Back



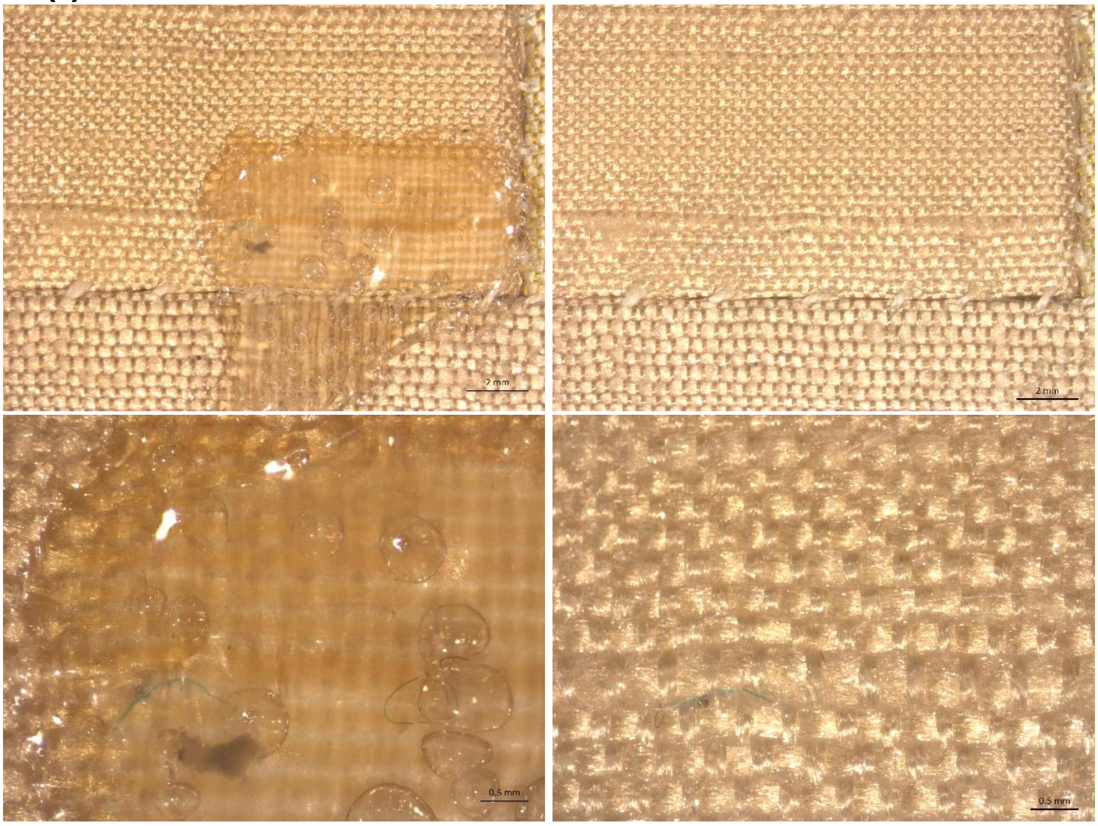
3a (3) Front



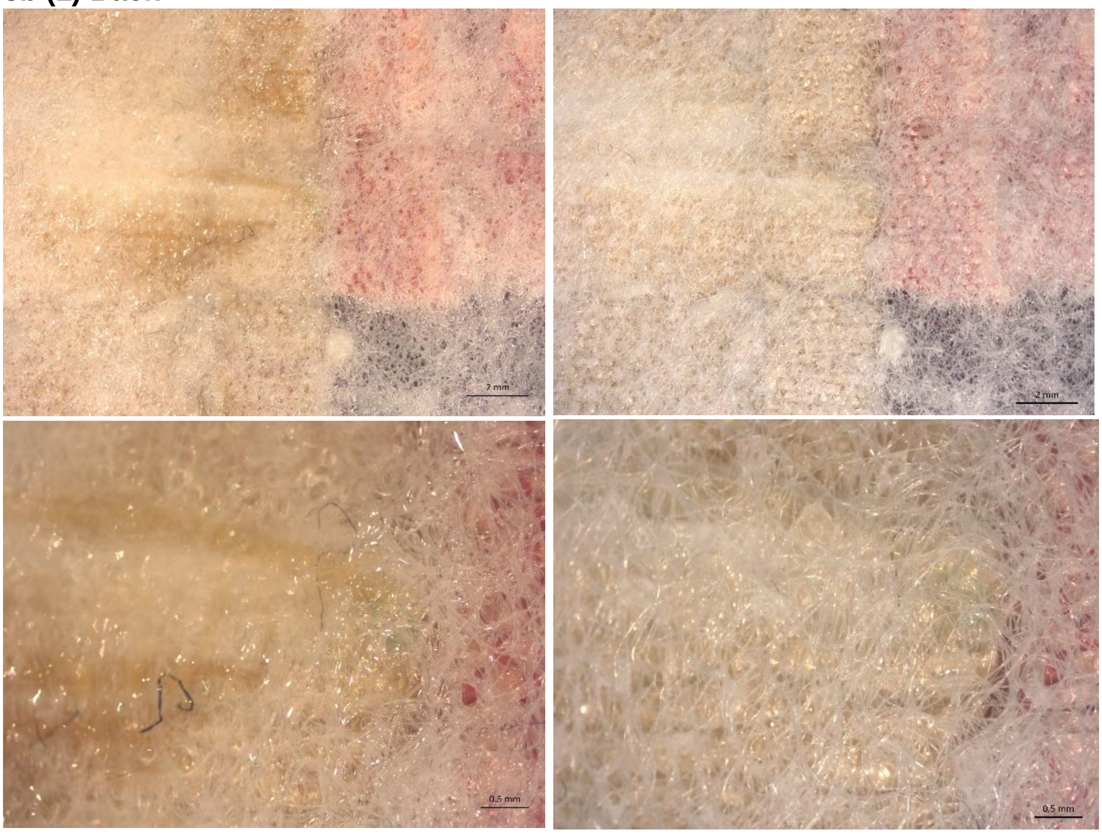
3a (3) Back



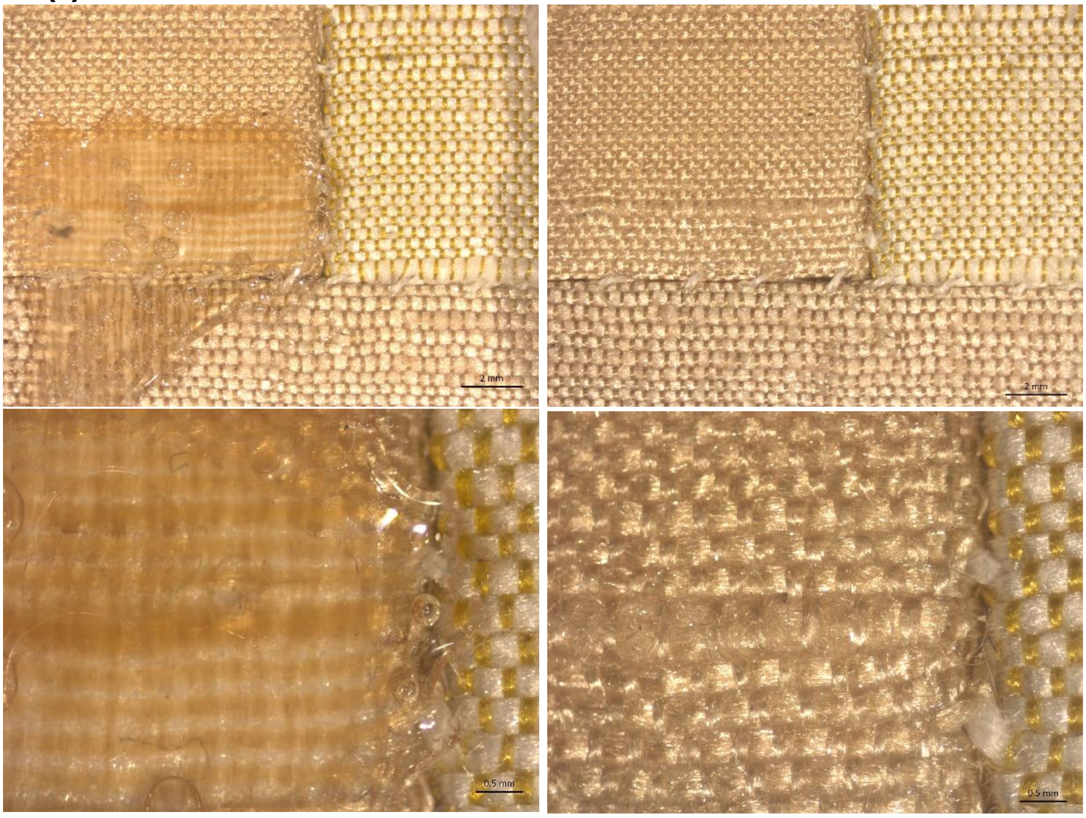
3b (1) Front



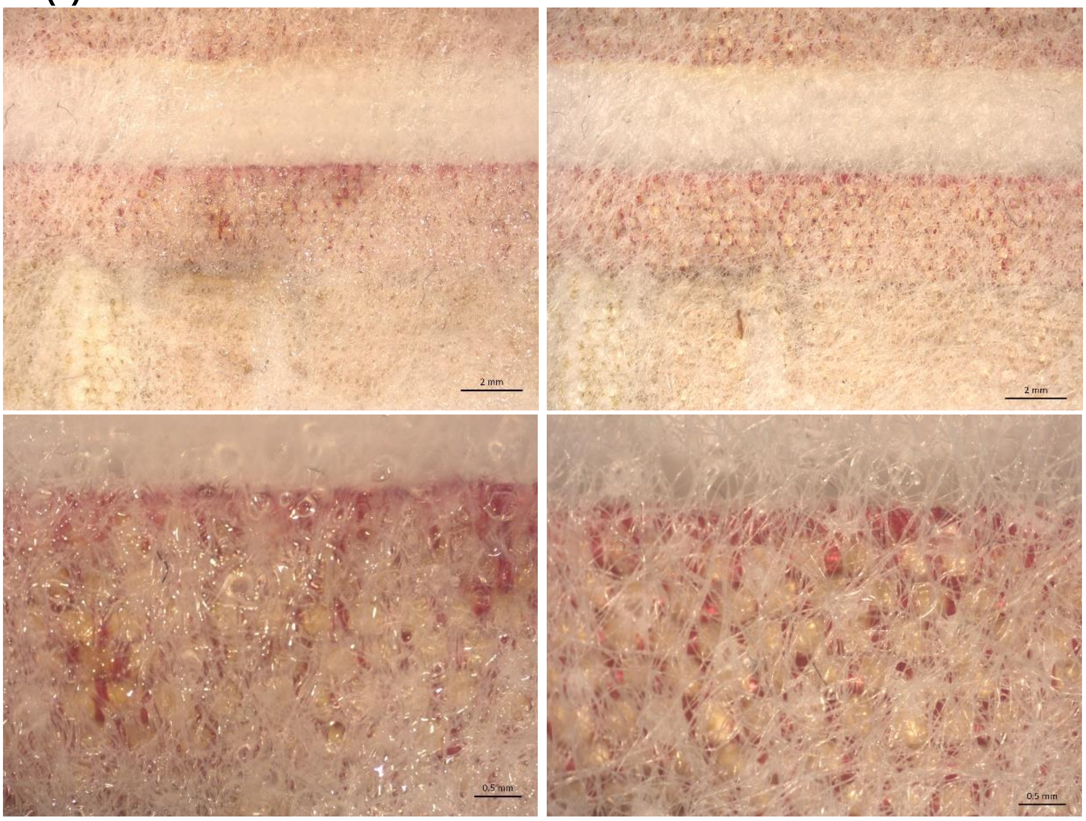
3b (1) Back



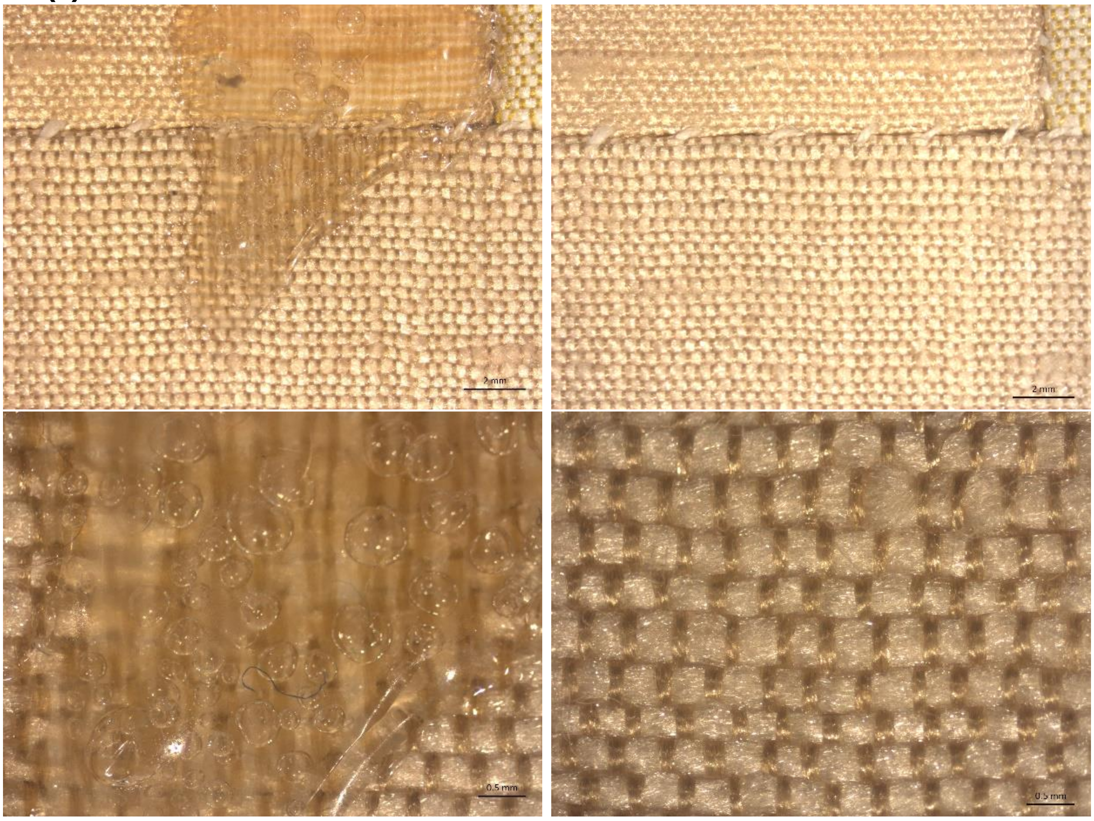
3b (2) Front



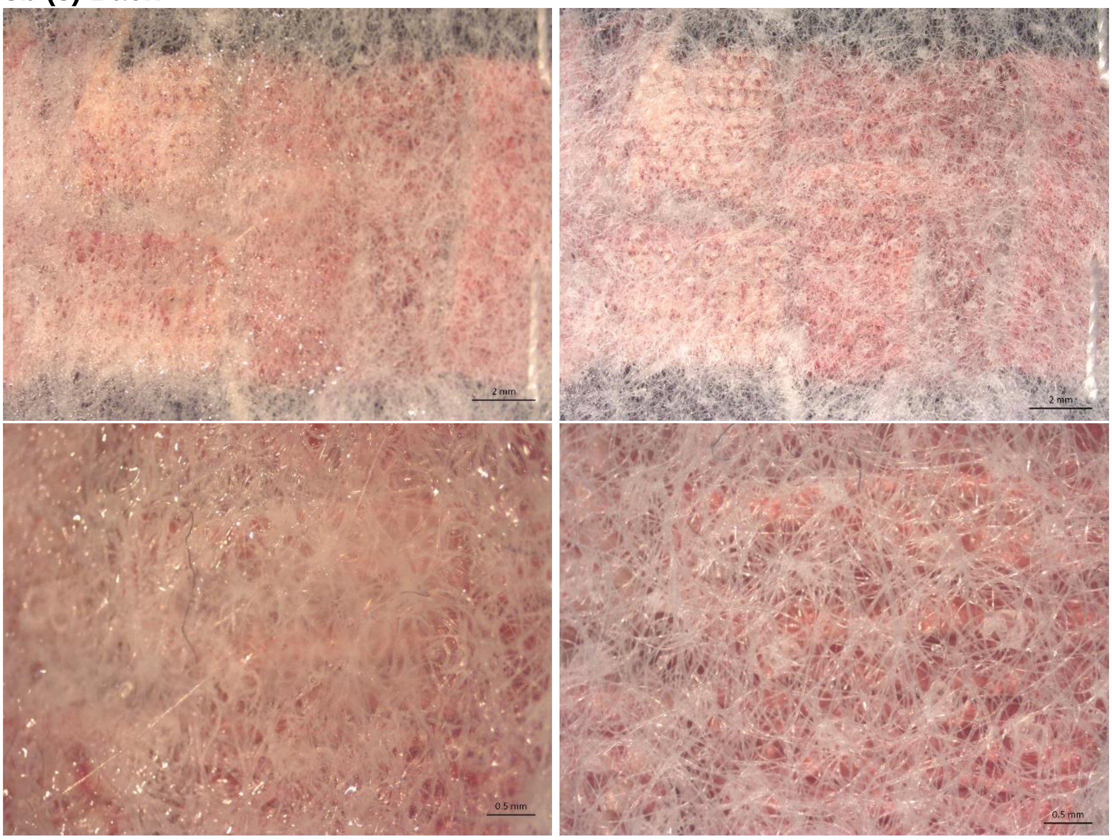
3b (2) Back



3b (3) Front

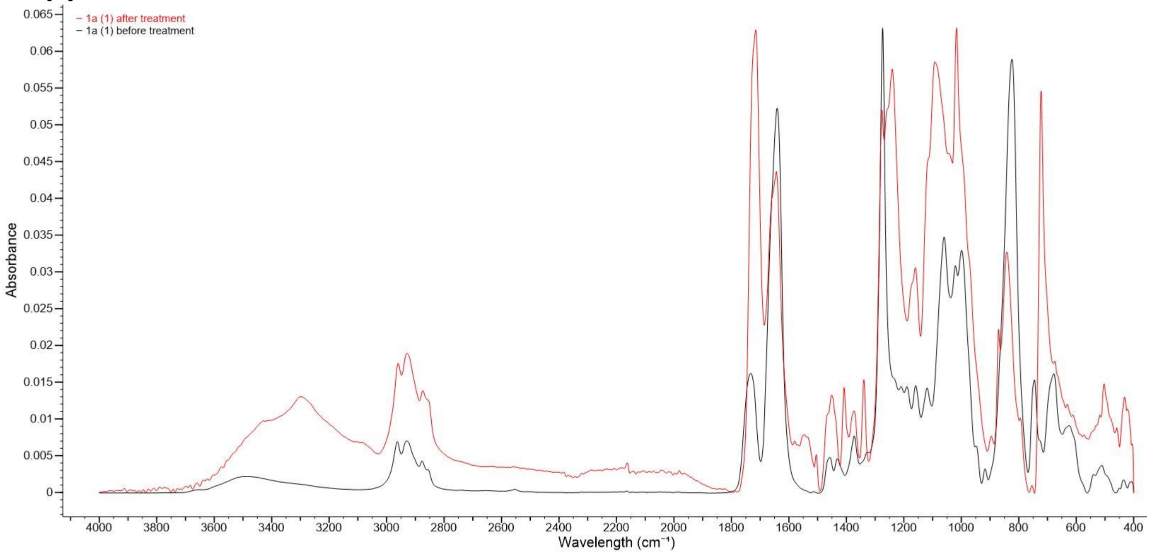


3b (3) Back

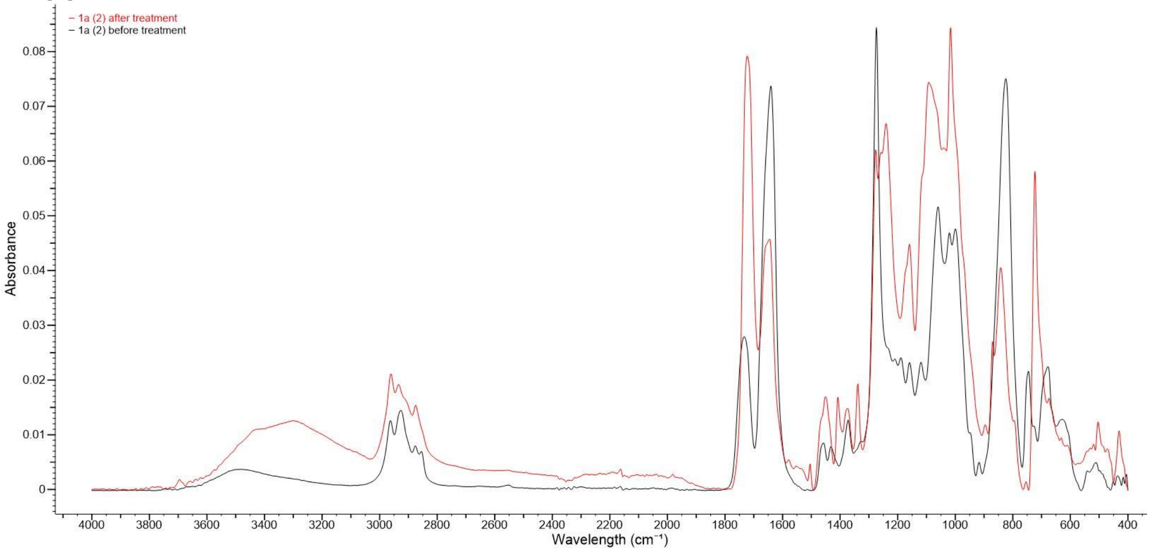


Appendix 11: FTIR spectra results from main testing

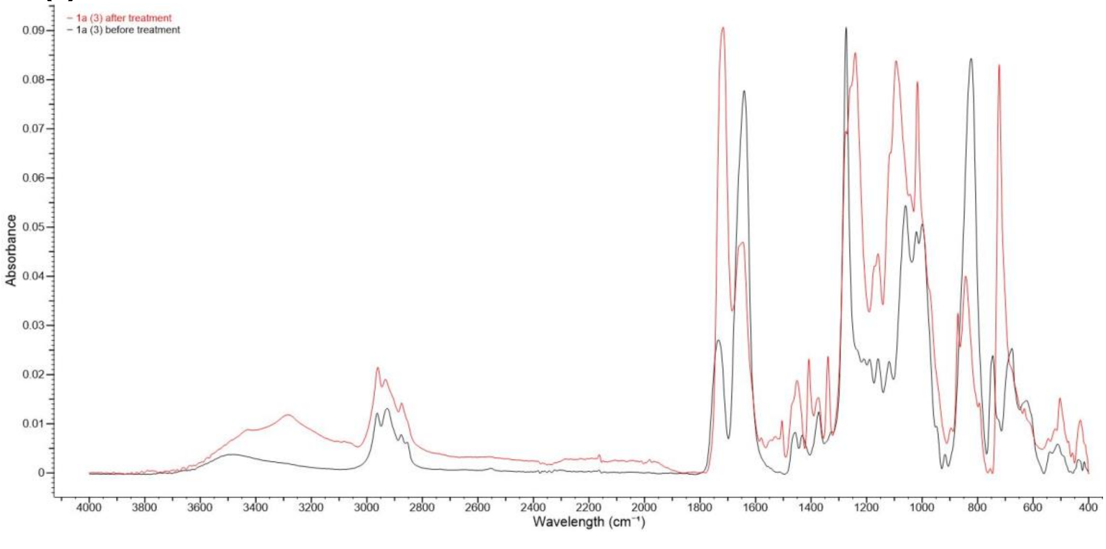
1a (1)



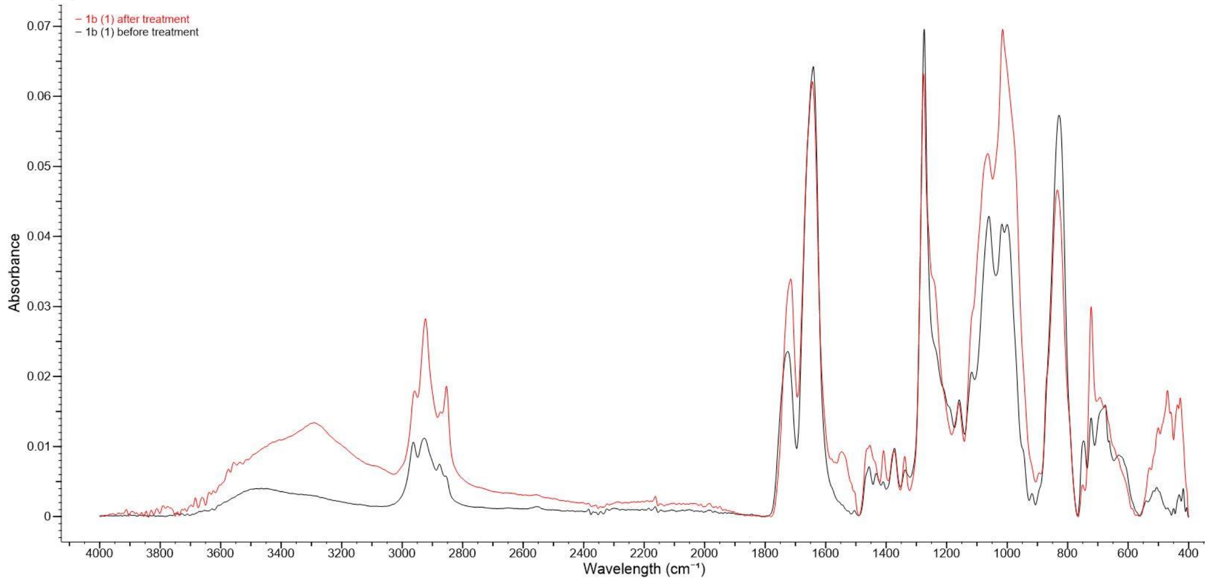
1a (2)



1a (3)

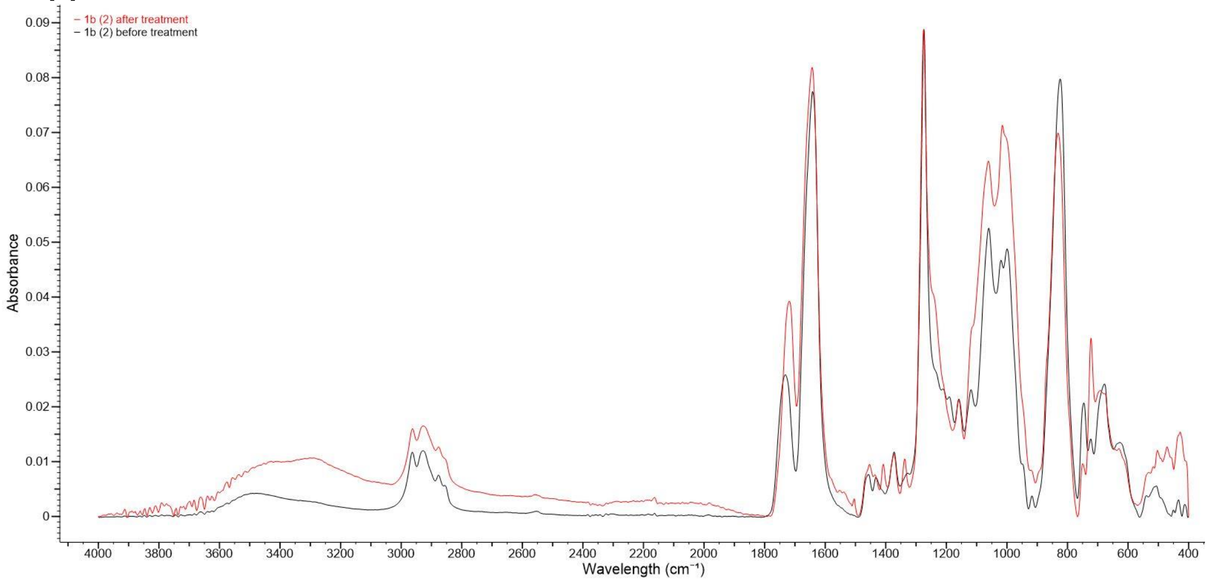


1b (1)



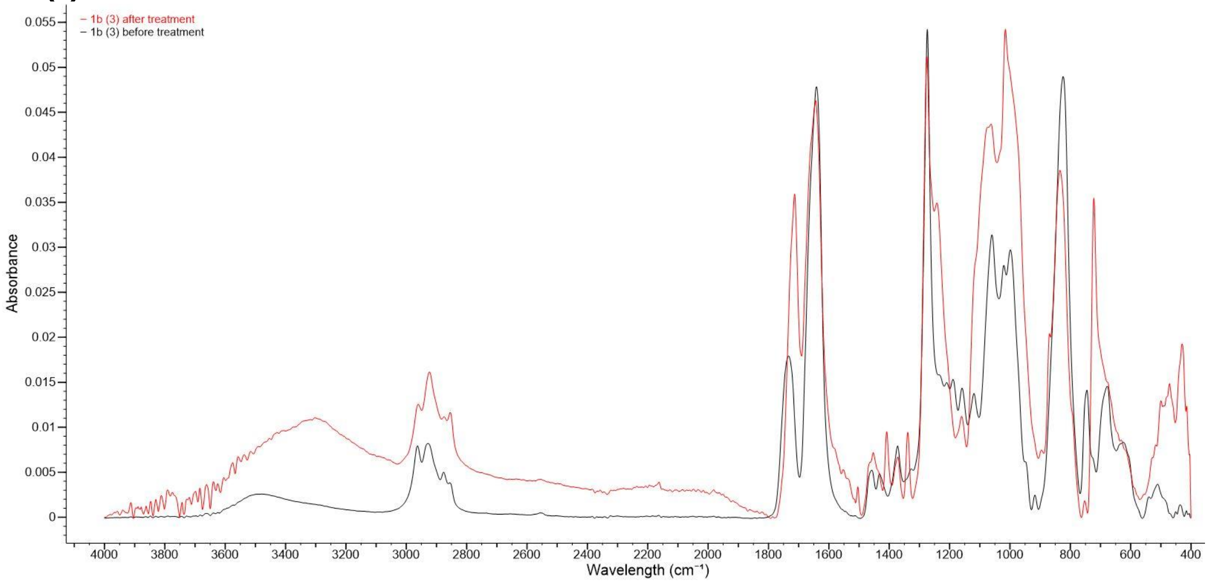
– 1b (1) after treatment
– 1b (1) before treatment
Absorbance
Wavelength (cm⁻¹)

1b (2)



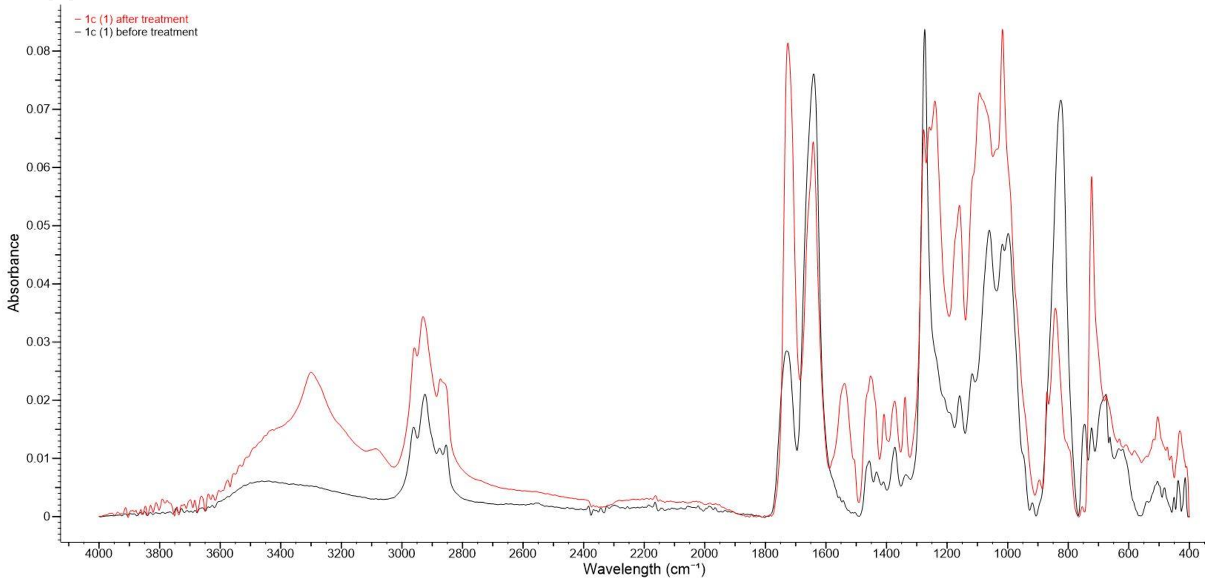
– 1b (2) after treatment
– 1b (2) before treatment
Absorbance
Wavelength (cm⁻¹)

1b (3)



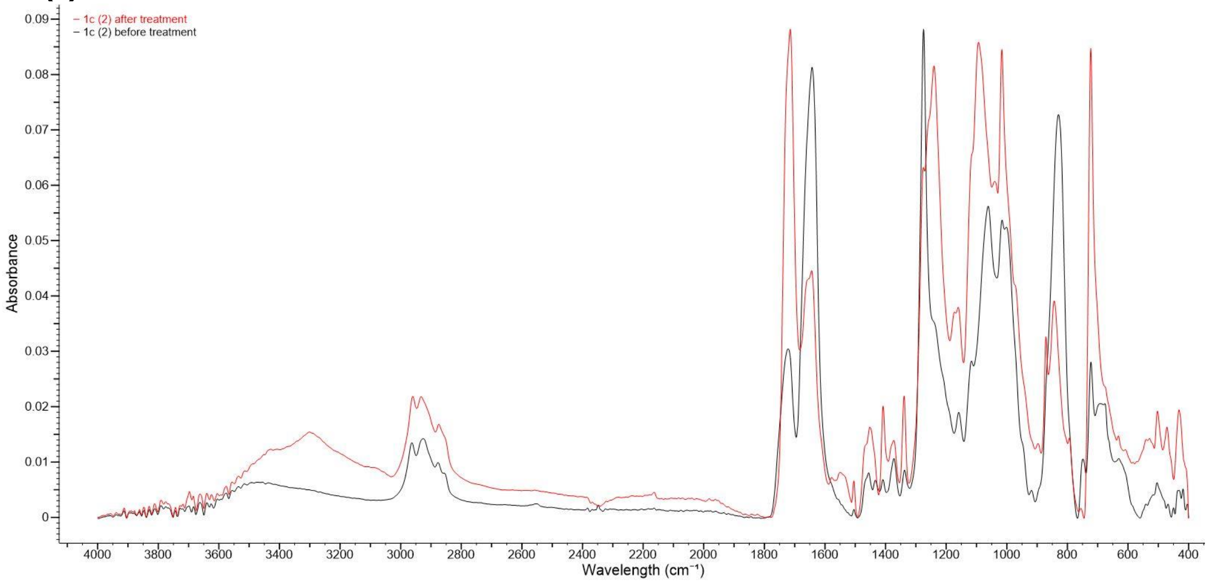
– 1b (3) after treatment
– 1b (3) before treatment
Absorbance
Wavelength (cm⁻¹)

1c (1)



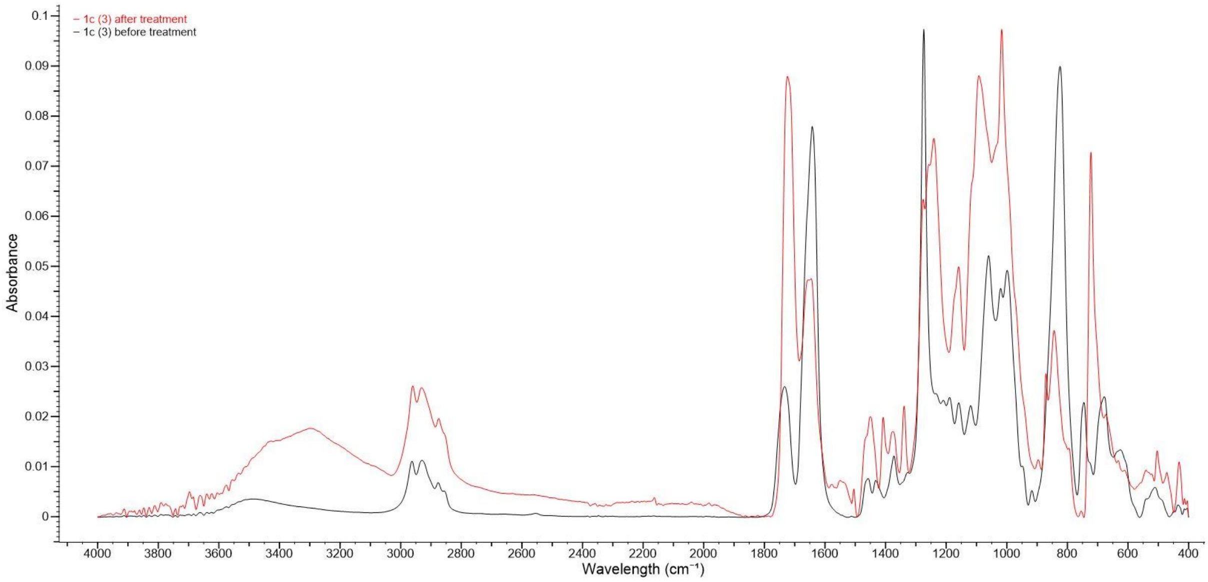
1c (1) after treatment
1c (1) before treatment
Absorbance
Wavelength (cm⁻¹)

1c (2)



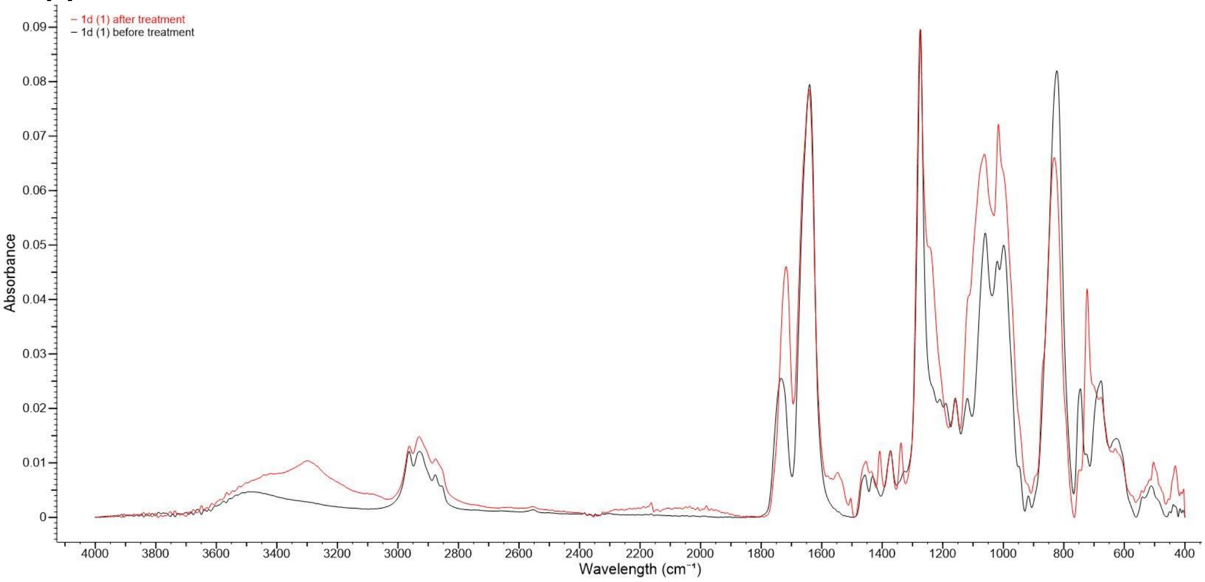
1c (2) after treatment
1c (2) before treatment
Absorbance
Wavelength (cm⁻¹)

1c (3)



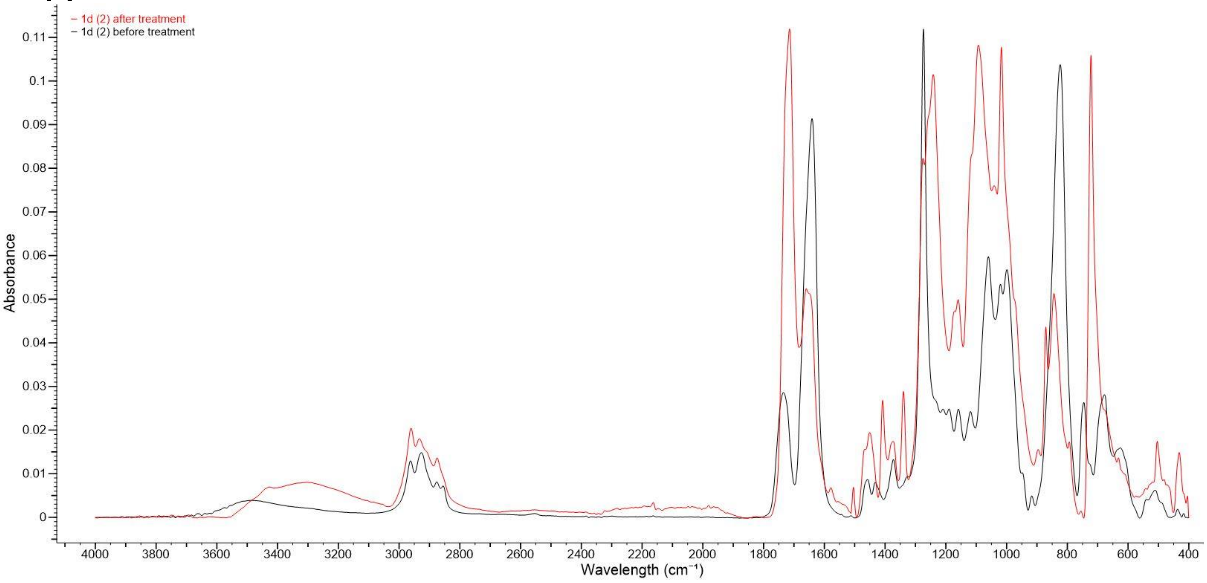
1c (3) after treatment
1c (3) before treatment
Absorbance
Wavelength (cm⁻¹)

1d (1)



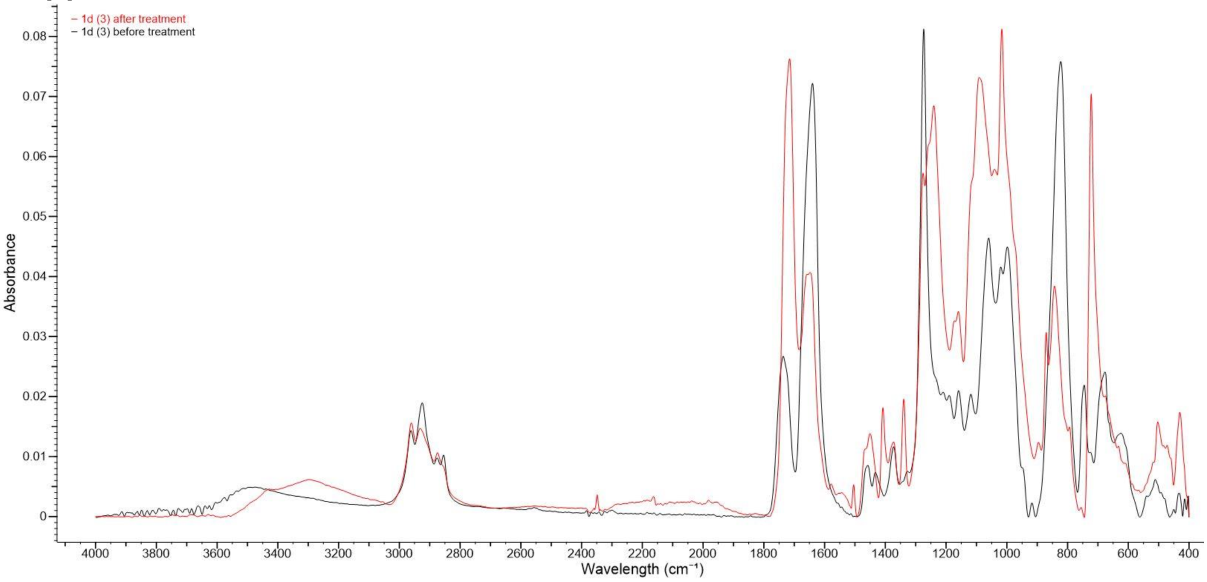
– 1d (1) after treatment
– 1d (1) before treatment
Absorbance
Wavelength (cm⁻¹)

1d (2)



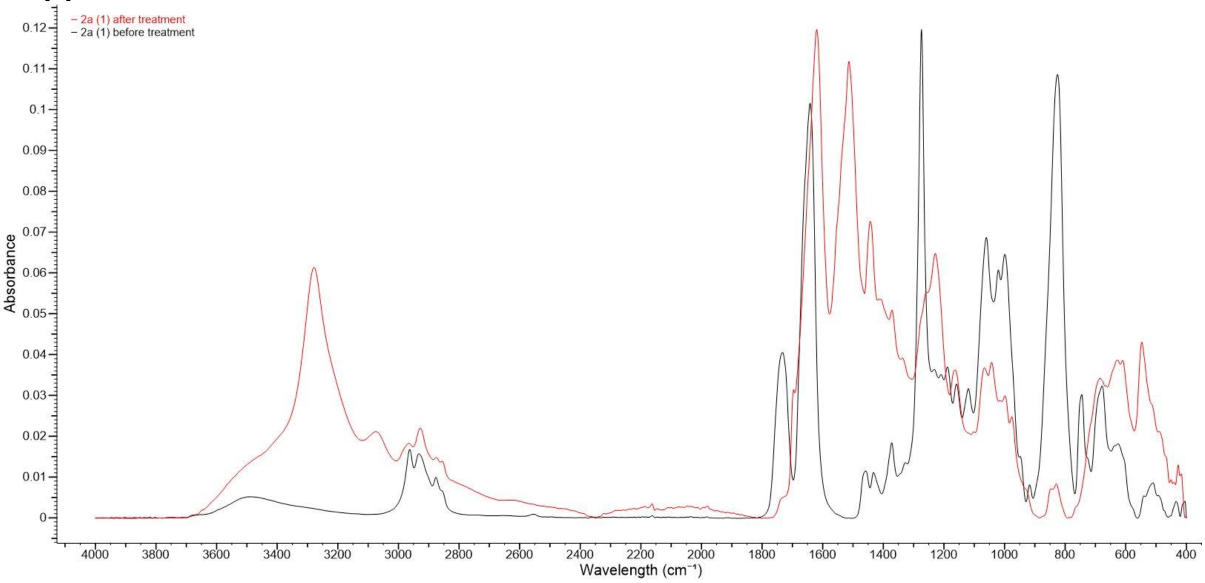
– 1d (2) after treatment
– 1d (2) before treatment
Absorbance
Wavelength (cm⁻¹)

1d (3)



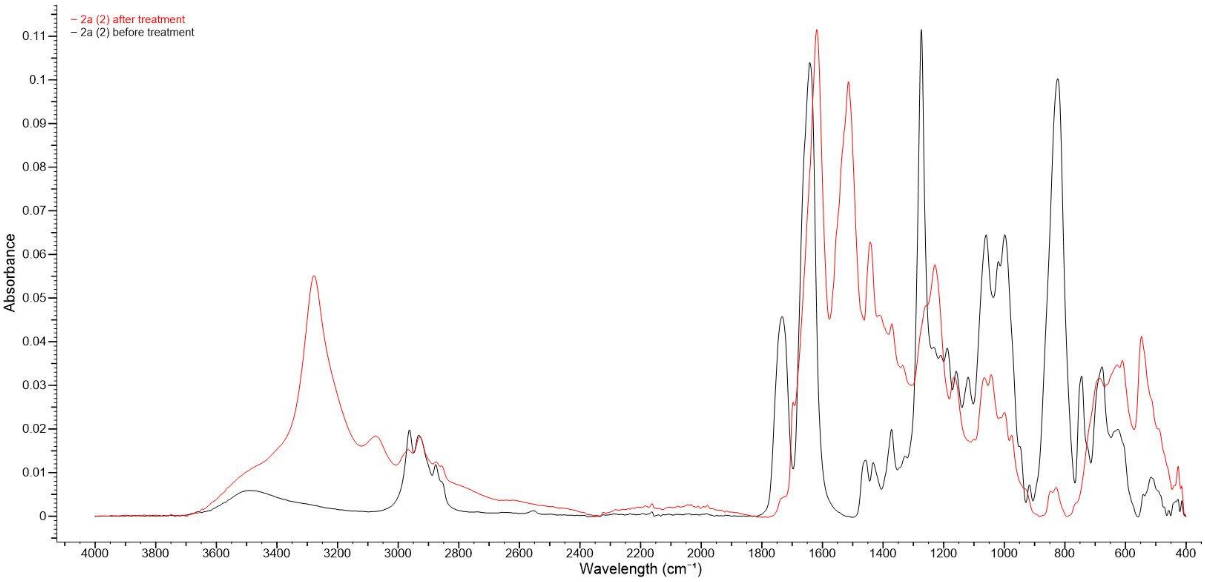
– 1d (3) after treatment
– 1d (3) before treatment
Absorbance
Wavelength (cm⁻¹)

2a (1)



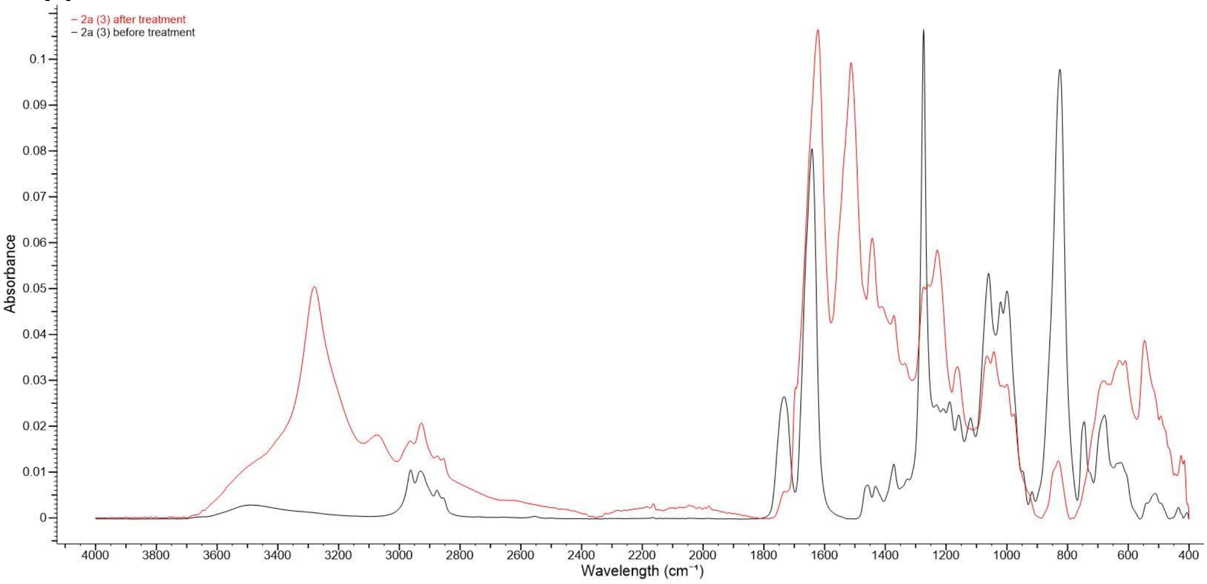
– 2a (1) after treatment
– 2a (1) before treatment
Absorbance
Wavelength (cm⁻¹)

2a (2)



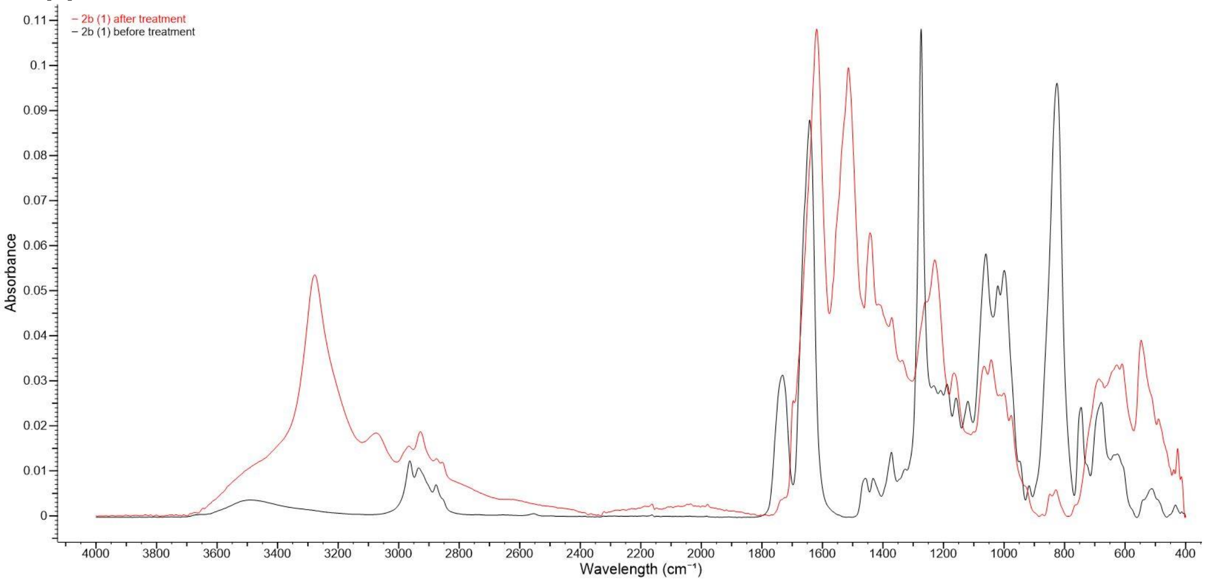
– 2a (2) after treatment
– 2a (2) before treatment
Absorbance
Wavelength (cm⁻¹)

2a (3)



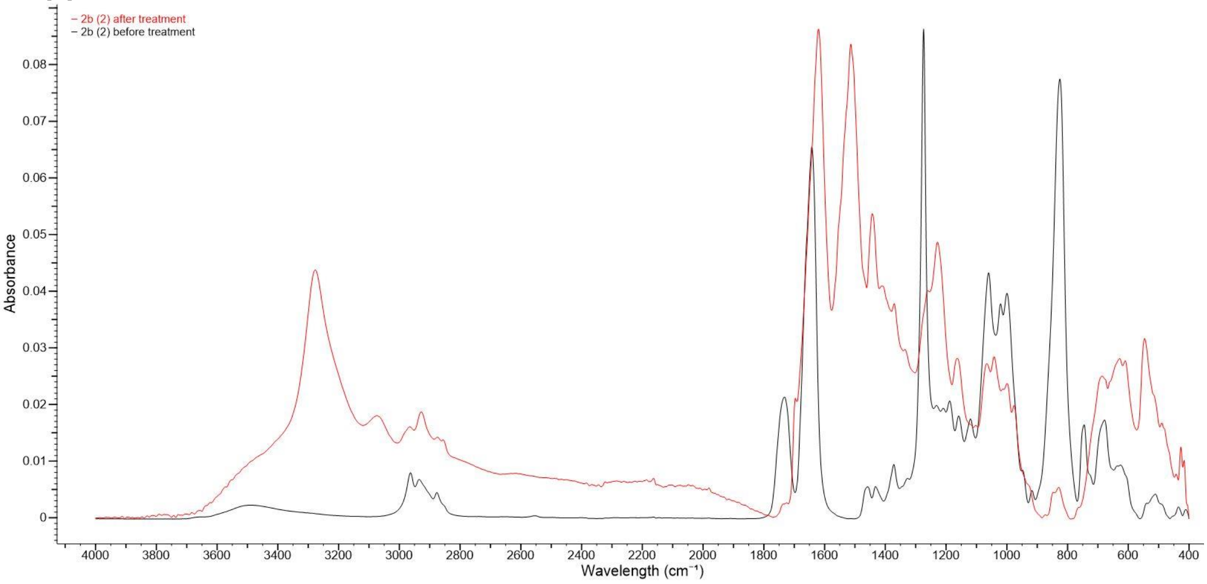
– 2a (3) after treatment
– 2a (3) before treatment
Absorbance
Wavelength (cm⁻¹)

2b (1)



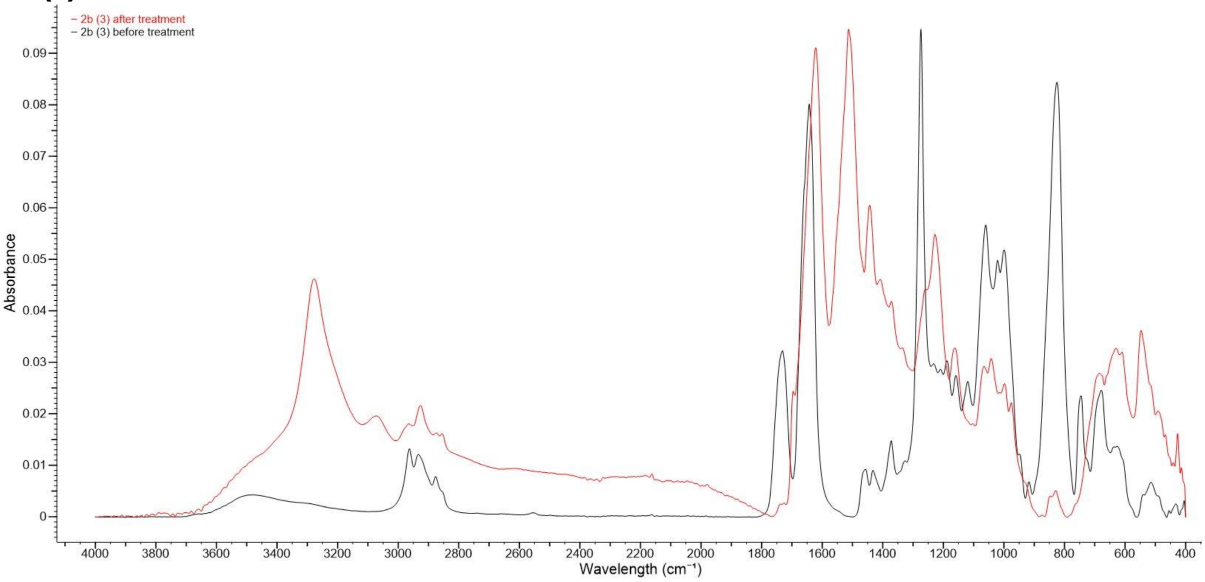
2b (1) after treatment
2b (1) before treatment
Absorbance
Wavelength (cm⁻¹)

2b (2)



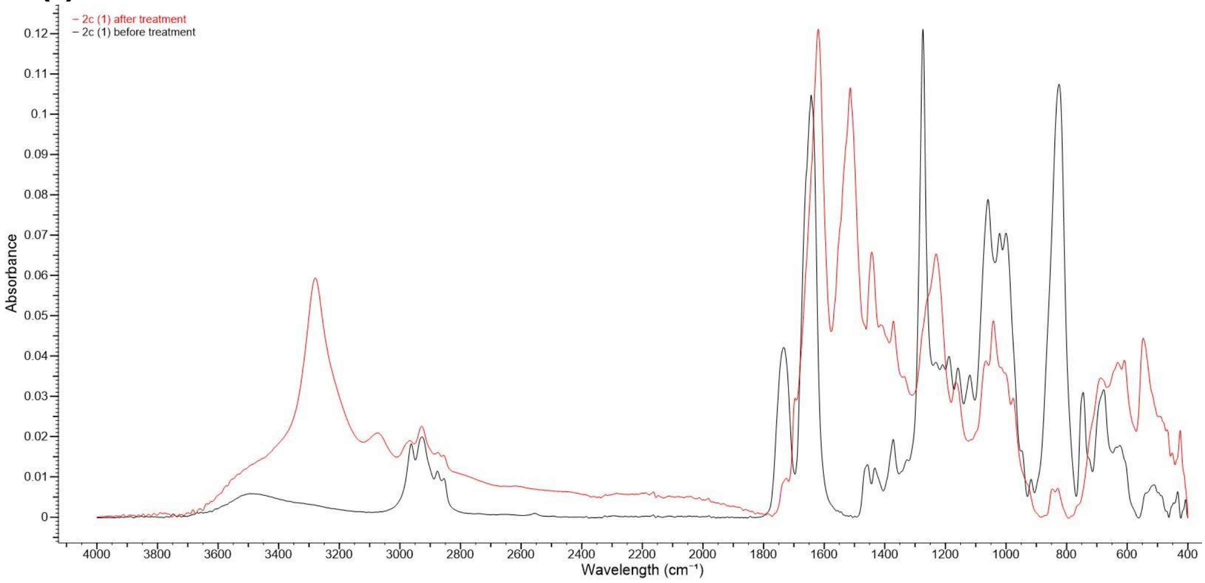
2b (2) after treatment
2b (2) before treatment
Absorbance
Wavelength (cm⁻¹)

2b (3)



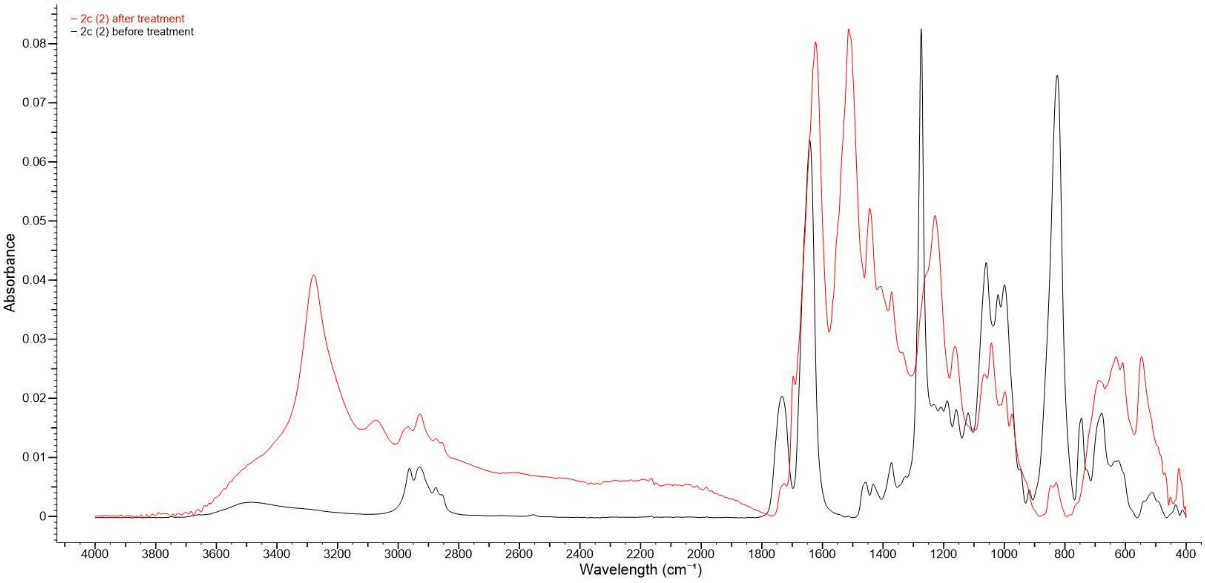
2b (3) after treatment
2b (3) before treatment
Absorbance
Wavelength (cm⁻¹)

2c (1)



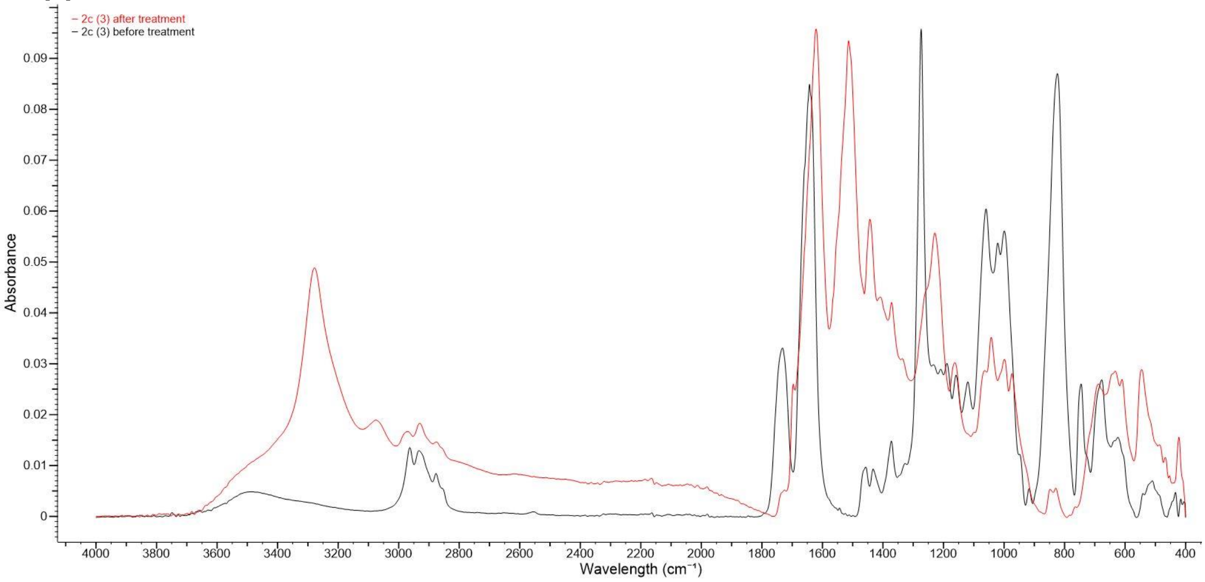
– 2c (1) after treatment
– 2c (1) before treatment
Absorbance
Wavelength (cm⁻¹)

2c (2)



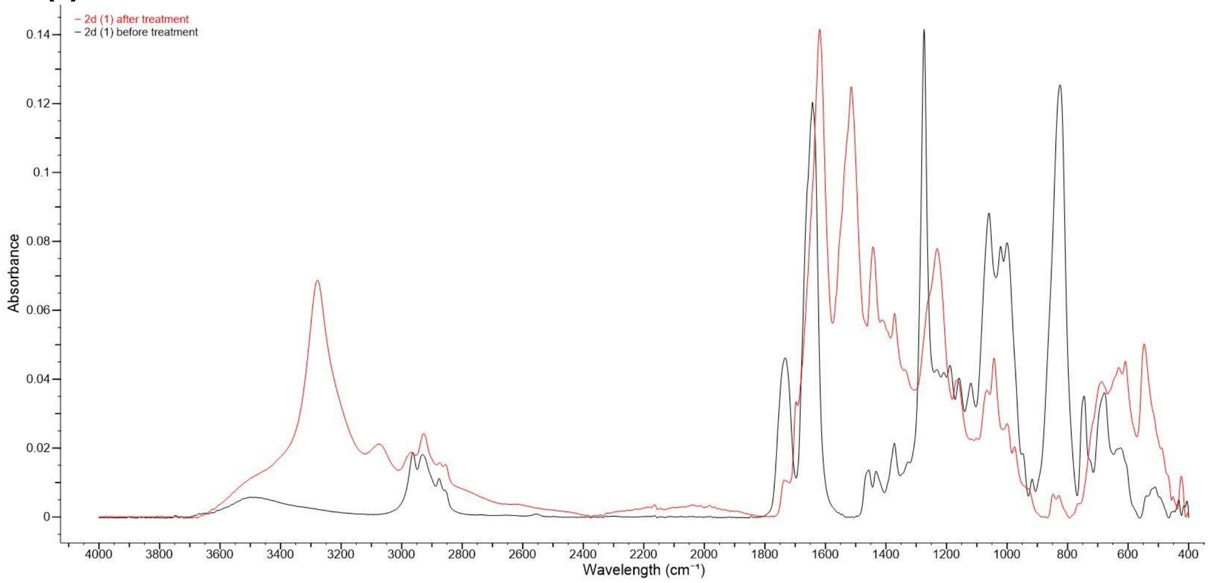
– 2c (2) after treatment
– 2c (2) before treatment
Absorbance
Wavelength (cm⁻¹)

2c (3)



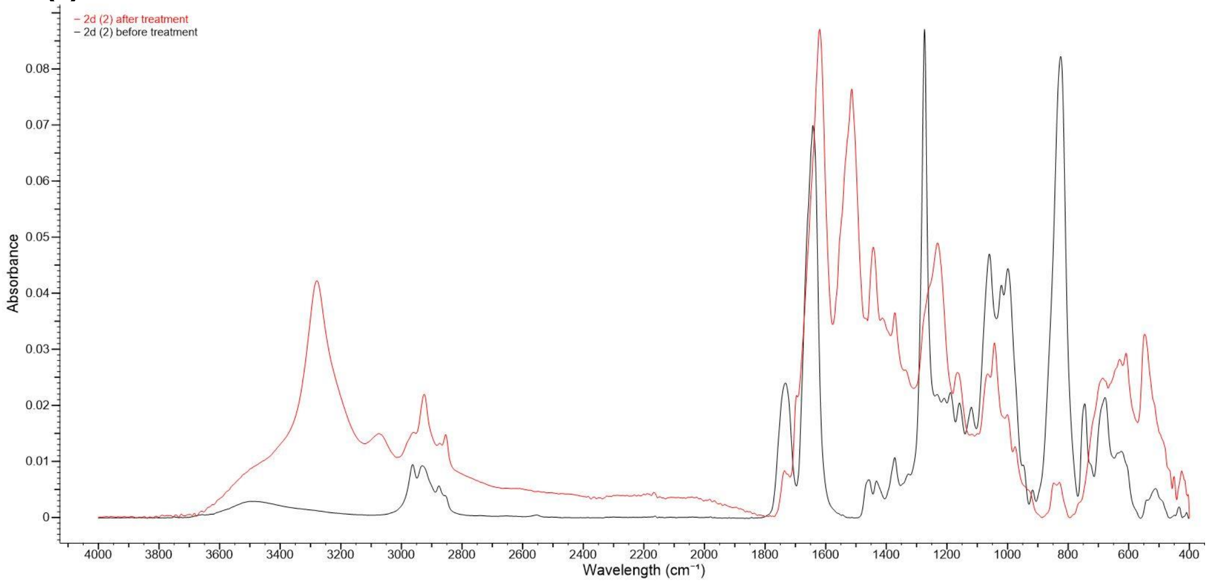
– 2c (3) after treatment
– 2c (3) before treatment
Absorbance
Wavelength (cm⁻¹)

2d (1)



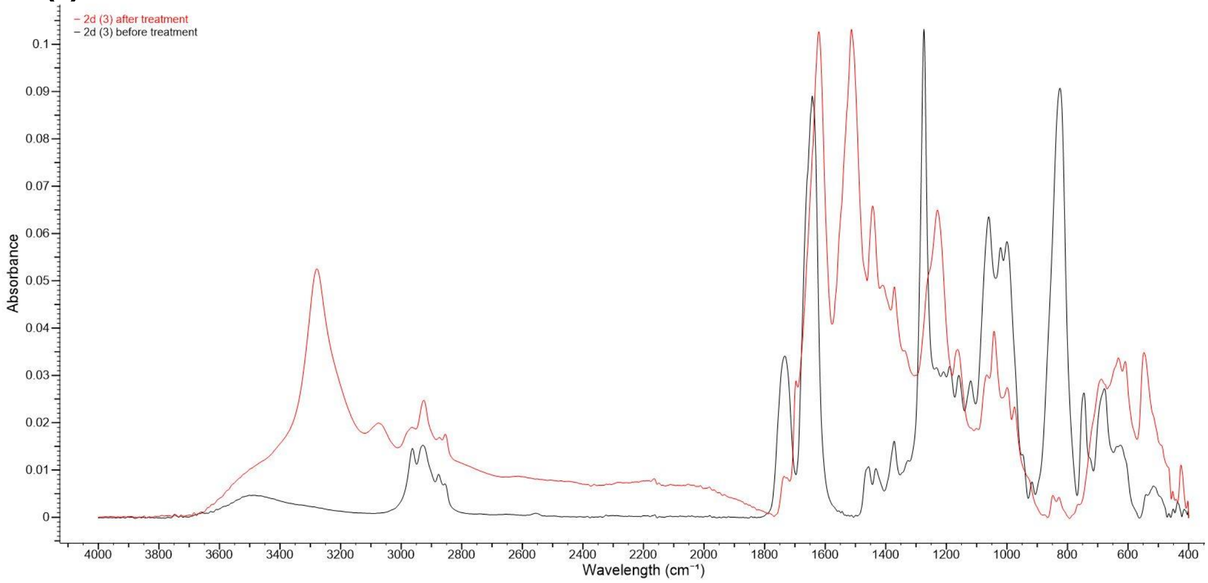
2d (1) after treatment
2d (1) before treatment
Absorbance
Wavelength (cm⁻¹)

2d (2)



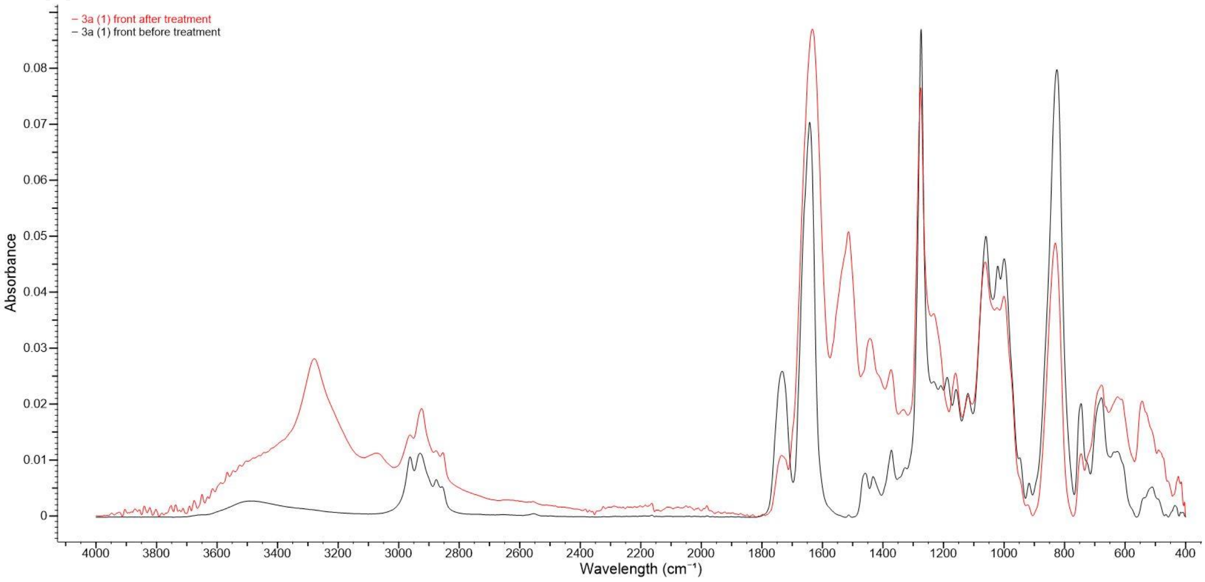
2d (2) after treatment
2d (2) before treatment
Absorbance
Wavelength (cm⁻¹)

2d (3)

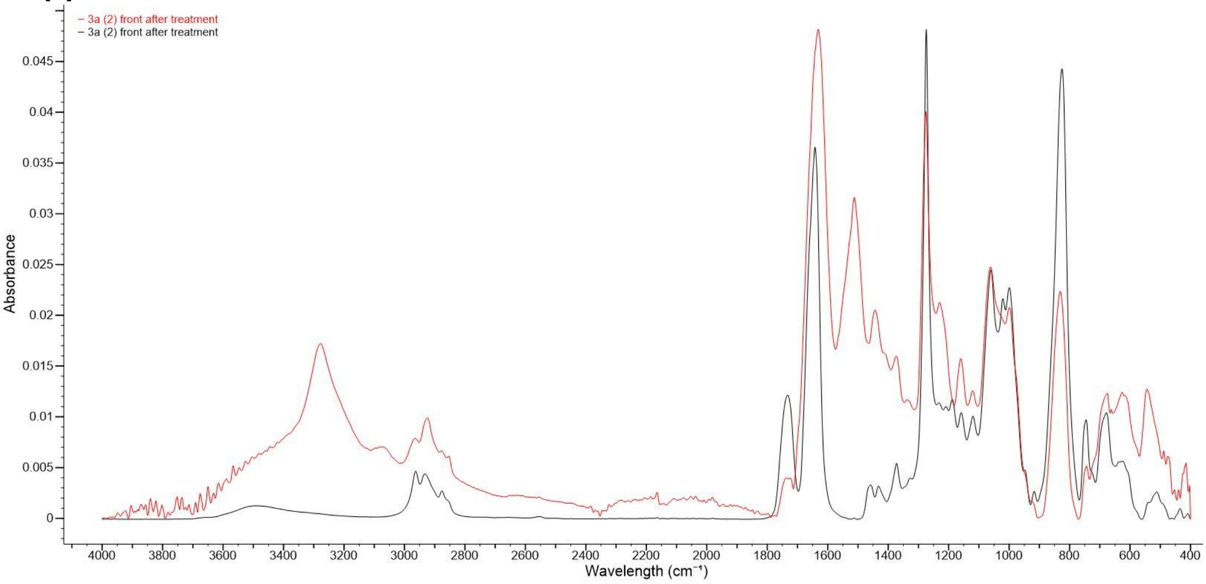


2d (3) after treatment
2d (3) before treatment
Absorbance
Wavelength (cm⁻¹)

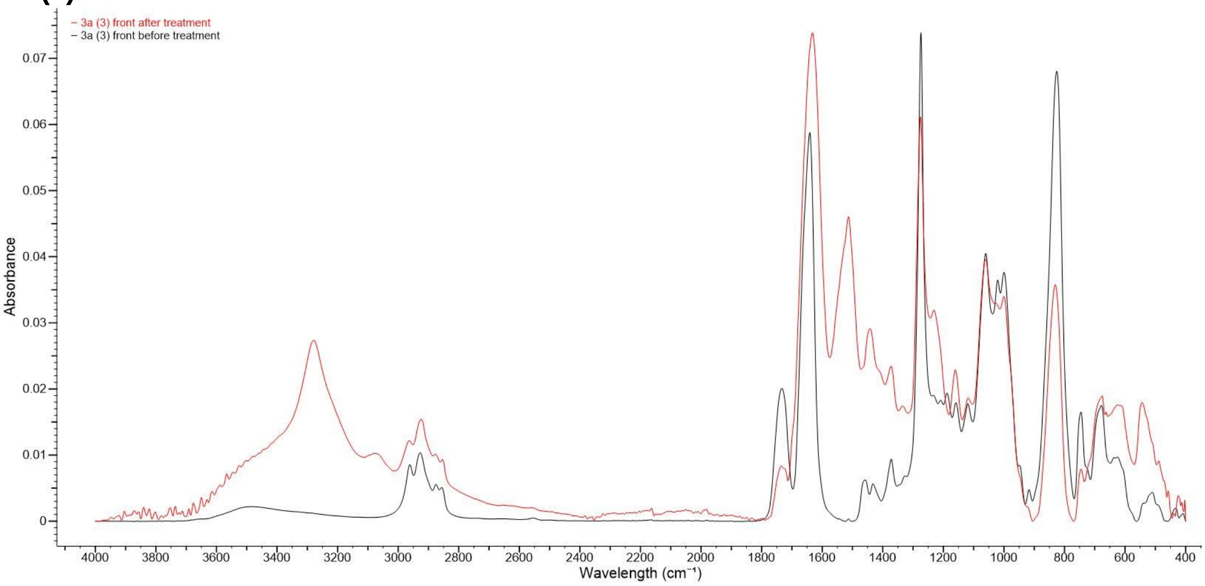
3a (1) Front



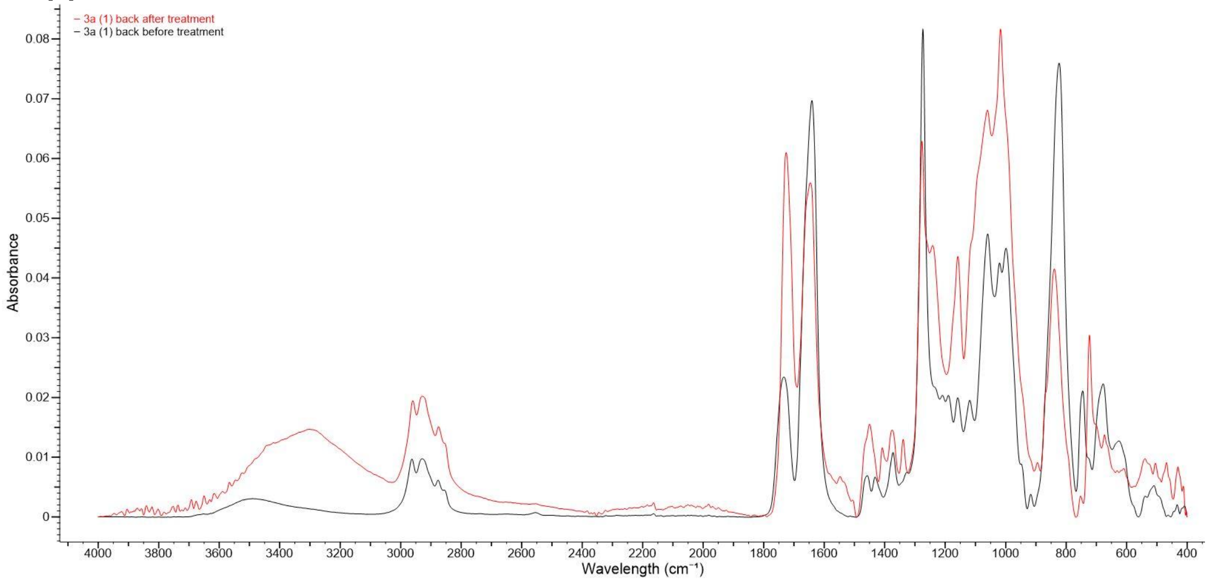
3a (2) Front



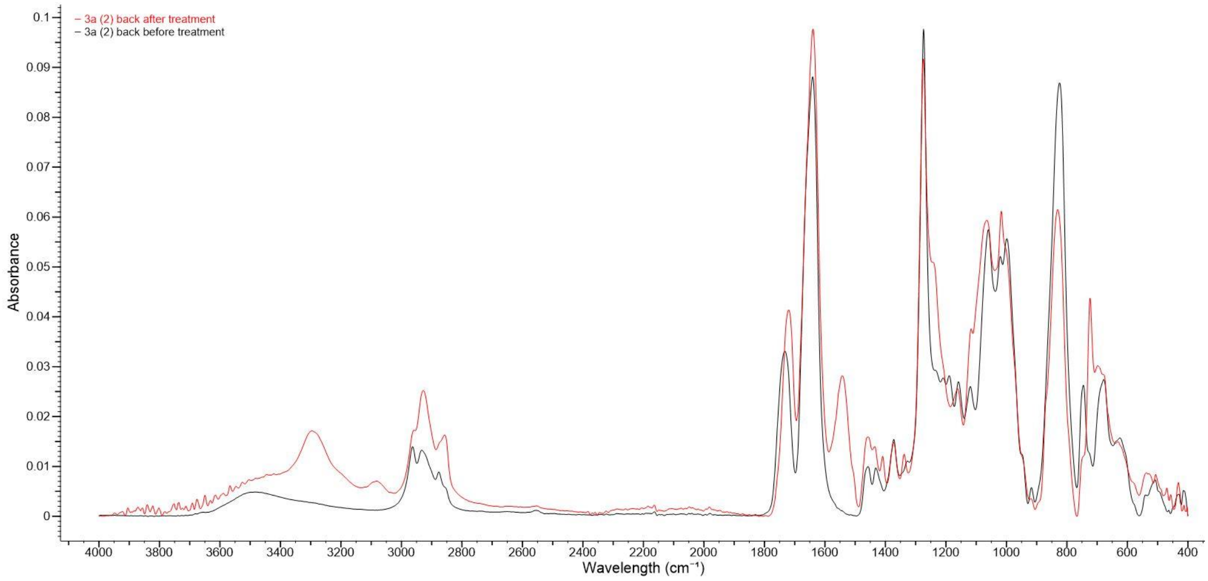
3a (3) Front



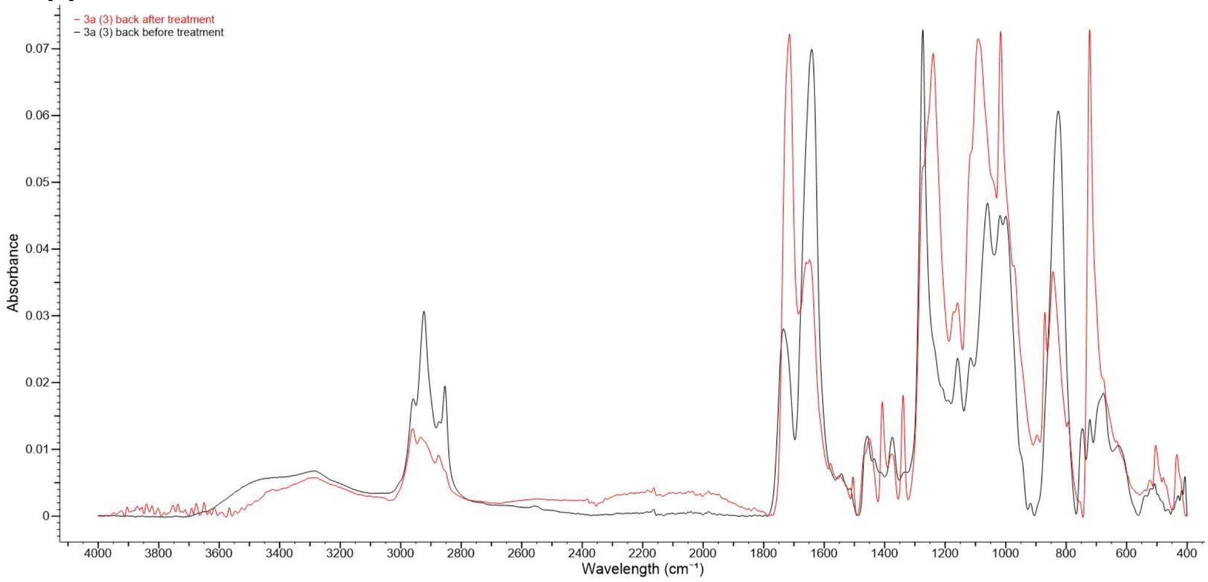
3a (1) Back



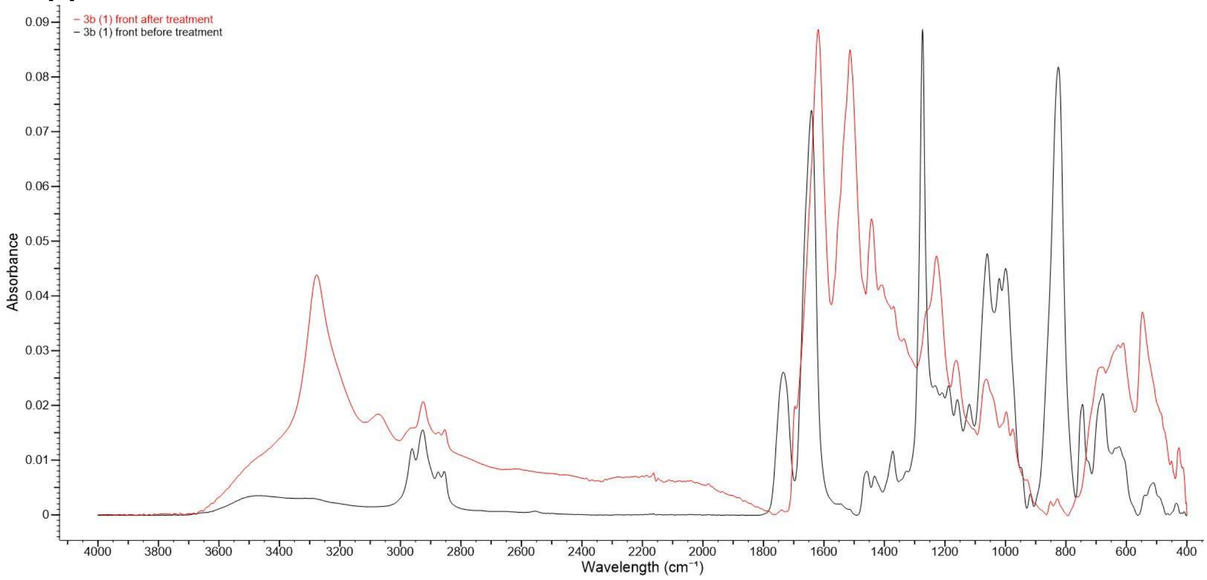
3a (2) Back



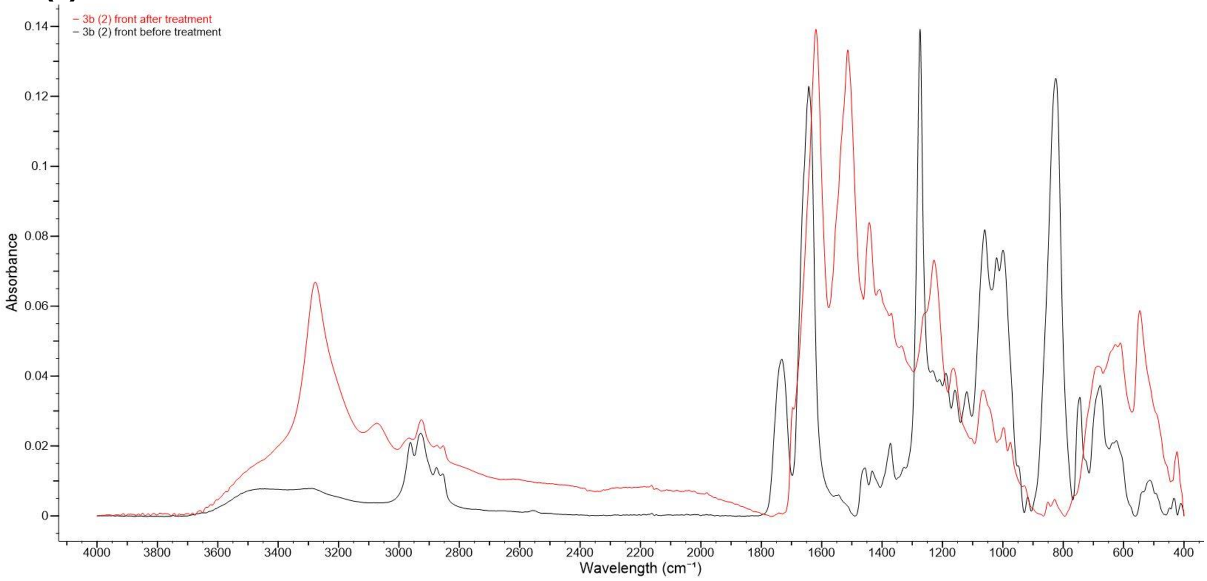
3a (3) Back



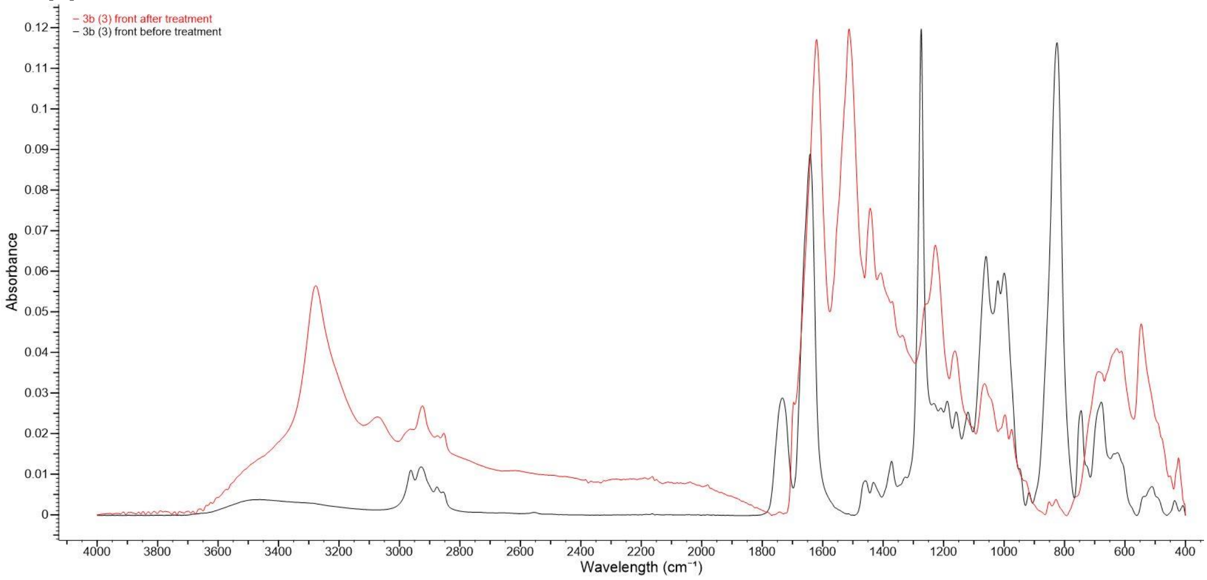
3b (1) Front



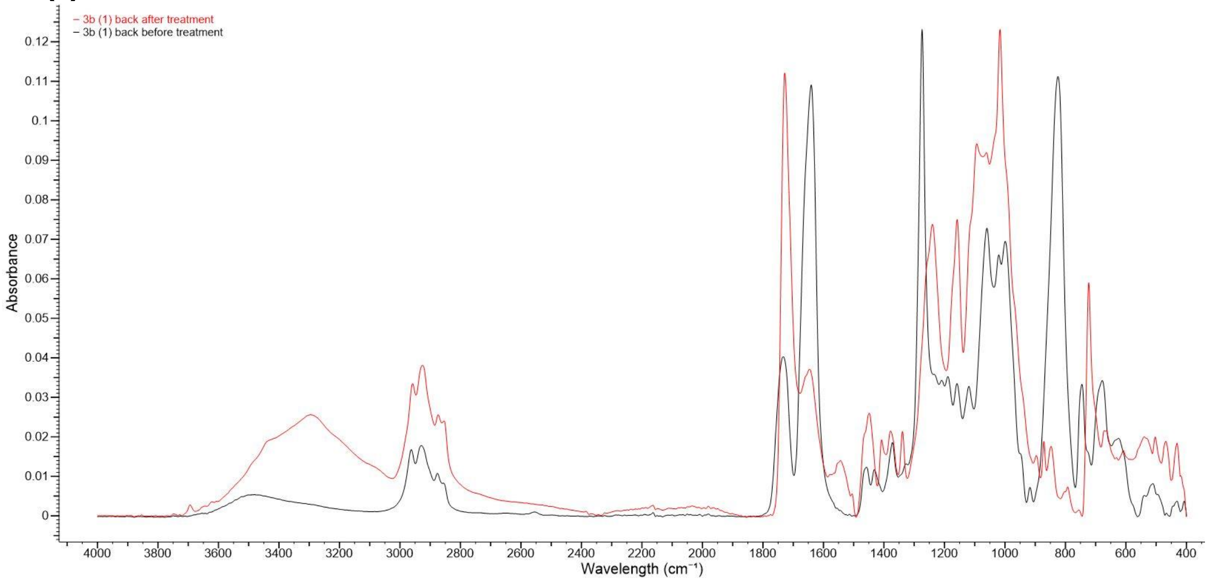
3b (2) Front



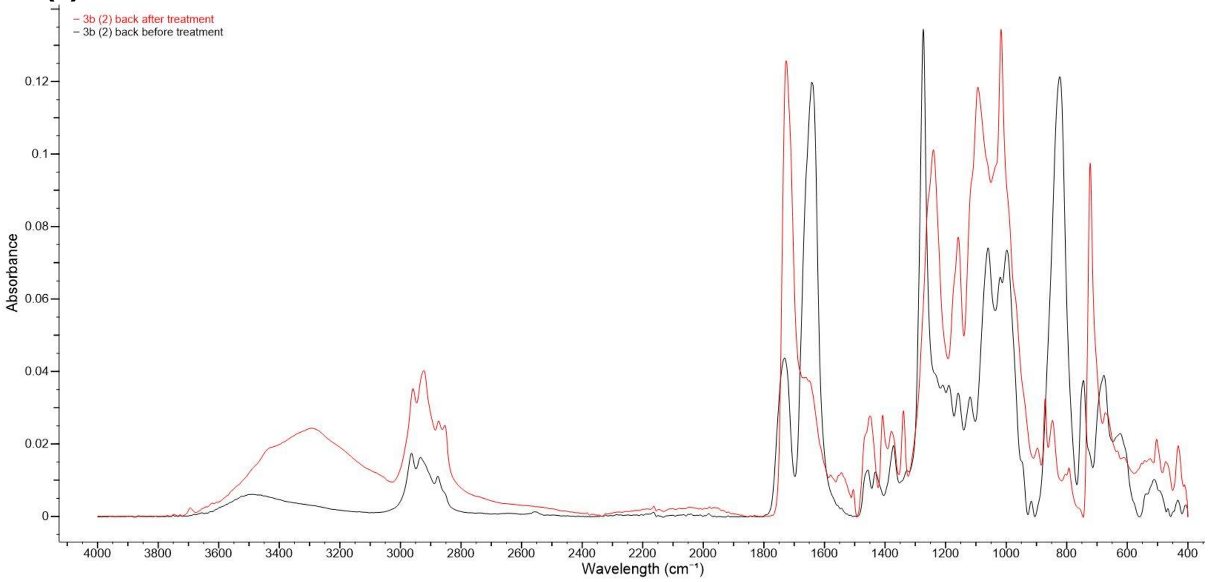
3b (3) Front



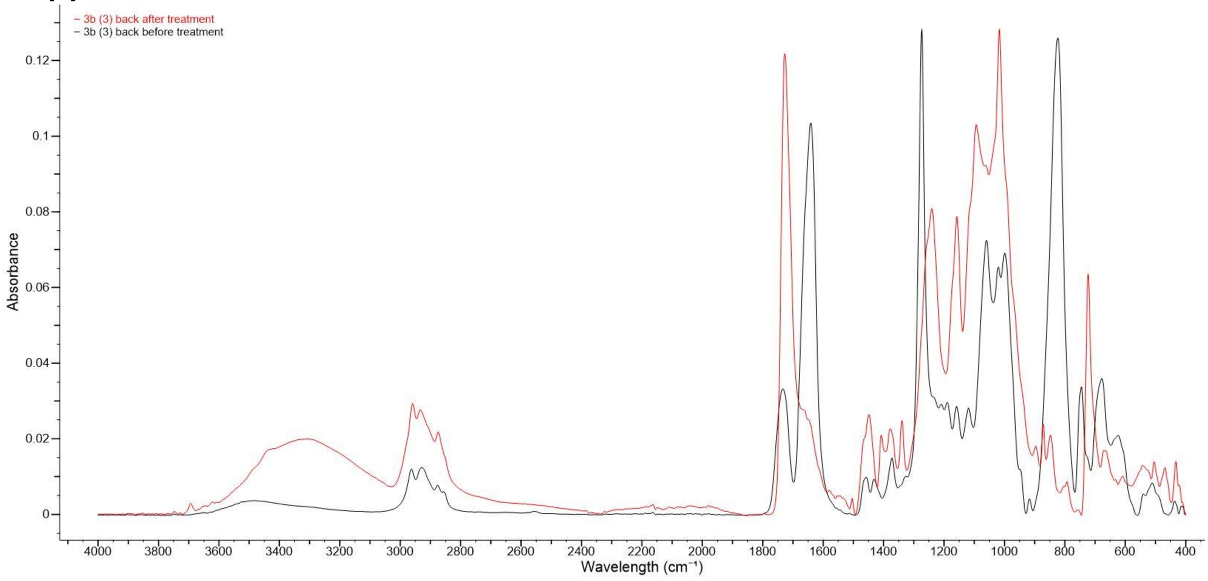
3b (1) Back



3b (2) Back

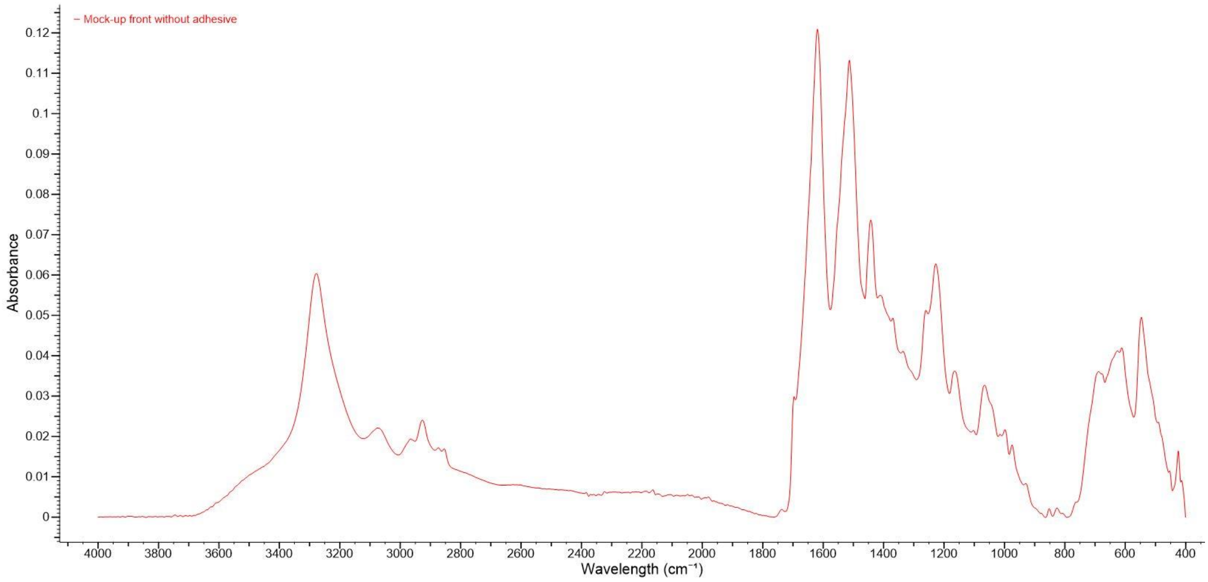


3b (3) Back

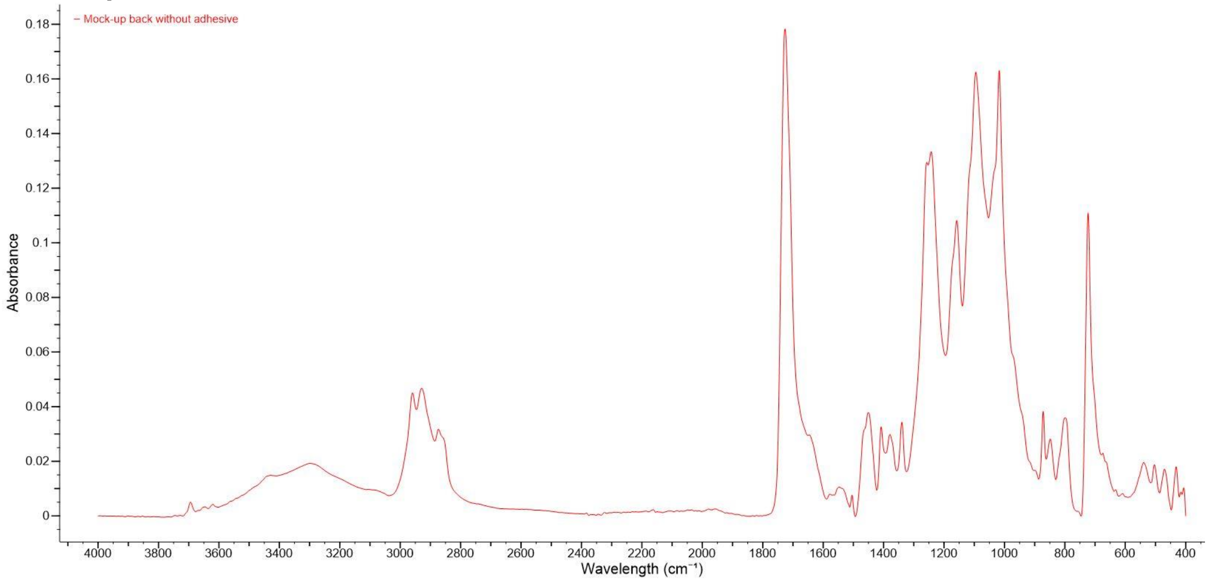


Control FTIR Reference Spectra

Mock-up front without adhesive



Mock-up back without adhesive



Appendix 12: Risk assessment and COSHH forms

University of Glasgow

General Risk Assessment

Risk Assessment Reference number:	R52	**Location:** (Site/ Building/ Room)	Level 3, Robertson Building
Assessment Date:	04.06.18	**Review Date:**	June 2020
Assessors Name:	Kim Tourret	**Job Title:**	Student

Task / Activity:
Investigation into a treatment methodology for CTC.443 *Golden Tangram* silk mosaic from the Whitworth Art Gallery.
The object will be photographed in the studio and visually examined. The adhesive on the reverse will be tested using FTIR – this will be undertaken in situ on the object and with samples removed with a scalpel. Samples will also be tested for the presence of cellulose nitrate using the diphenylamine test.
The adhesive will undergo solubility testing with a variety of solvents.
Mock-ups of the object may be artificially aged in the accelerated aging oven. Removal of the adhesive from the mock-ups will be tested in a variety of ways, including using the suction table and a variety of poultices. The mock-ups will then be deconstructed and visually examined.
See COOSH forms: R52/C1, R52/C2 & R52/C3

What are the hazards? (See list of sample hazards)	What are the risks?	Who might be harmed? (eg Staff, students, visitors)	What control measures are required to eliminate or reduce the risks?	Risk Evaluation			Risk Rating
				Consequence (1 – 3)	Likelihood (1 – 3)	Overall risk (C x L)	Low, Medium or High
Slips, trips and falls	Harm to health (physical and chemical) Spillage/breakage of items Damage to historic objects	Students, staff, cleaners, visitors	Good workroom practice, cover leads where trailing, mop up spillages and ensure routes in workroom are clear	1	2	2	Low
Electrical hazards	Harm to health (physical)	Students, staff, cleaners, visitors	Unplug and switch off equipment when not in use and avoid trip hazards. Ensure equipment is in good working order (including visual check) and has been PAT tested.	2	1	2	Low
Chemicals	Harm to health, spills	Students, staff, cleaners, visitors	See COSSH assessments R52/C1 and R52/C2. PPE including gloves, labcoats (sleeves not rolled up, goggles, long hair tied back, no loose jewellery). Ensure appropriate dispensers are used and smallest quantities of chemical used where possible. If larger quantities are required, use the solvent carrier to transport. Chemical spills to be cleaned following	3	1	3	Mediu m

			COSSH guidance using spill kit in chem lab 310 and wet room 315, or using paper towels as appropriate. All chemicals to be labelled appropriately. Suction table to be emptied and waste disposed of appropriately after use.				
Use of sharp hand tools	Cuts	Students, staff, cleaners, visitors	Use cutting mats where appropriate. Follow good practice for cutting. First aid kit in wet room 315. Use surgical blade remover (in chem lab 310) to change blade on scalpels. Dispose of old blades/broken needles in sharps disposal box under the sink in chem lab 310.	1	2	2	Low
Glassware breakage	Cuts	Students, staff, cleaners, visitors	Ensure suitable space available when using glassware. Take care when handling. Damaged glassware to be reported and breakages cleaned up with dustpan and brush kept under the sink in wet lab 315. Chipped and damaged glassware put in box for possible repair. Broken glassware put in designated disposal boxes in chem lab 310 and wet room 315.	1	2	2	Low
Completed by (print name, position, and sign): Kim Tourret				**Date:** 05.06.18			
Approved by (print name, position, and sign): Karen Thompson				**Date:** 05.06.18			

University of Glasgow — CoSHH Assessment

Assessment Title: Dissertation research project – Diphenylamine spot test for cellulose nitrate

Assessment Reference Number: R52/C1

School / Service / Location: CTCTAH, Level 3 Robertson Building

Safety Coordinator: Karen Thompson

Details of Hazardous Substances (Please attach safety datasheets where available)

Name of Substance (Include all substances used or produced)	Quantity kg / g / ml	Physical Form	GHS Hazard Classification (Tick all that apply): Explosive	Flammable	Oxidising	Gas under pressure	Harmful/Irritant	Corrosive	Toxic	Health hazard	Environmental hazard
1.Diphenylamine	0.5g	Solid							X	X	X
2.Sulphuric acid	90ml (concentrated)	Liquid					X	X			
3.											
4.											
5.											
6.											

Special Hazards (*Separate risk assessment may be required)

	Details
Carcinogenic Substance	**Details:** Exposure to strong inorganic mists containing sulphuric acid is carcinogenic.
Skin Sensitiser	**Details:** Sulphuric acid causes severe skin burns and eye damage.
Respiratory Sensitiser	**Details:** Do not breath dust/fume/gas/mist/ vapours/spray
Biological Material*	**Details:**
Radioactive Substances*	**Details:**
Explosive Atmosphere*	**Details:**

Further Details / Other Special Hazards: Diphenylamine Is acutely toxic if ingested, inhaled or through skin contact and can cause damage to organs through prolonged or repeated exposure. Diphenylamine is very toxic to aquatic life and should not be disposed of down the sink. Sulphuric acid is also hazardous to the environment.

Exposure to Hazardous Substances

Substance	Possible Exposure Route (Please tick): Inhalation	Ingestion	Skin	Injection	Other (State)	Workplace Exposure Limits: 8h TWA	15min STEL
1. Diphenylamine	X	X	X			10 mg/m^3	20 mg/m^3
2. Sulphuric acid	X	X	X			0.05 mg/m^3	0.15 mg/m^3
3.							
4.							
5.							
6.							

Description of Activity (Continue on a separate sheet if required)

Diphenylamine spot test for cellulose nitrate using a solution of 0.5% diphenylamine in 90% sulphuric acid. 100ml solution will be made. 90ml concentrated sulphuric acid will be added slowly to 10ml water while stirring continuously to prevent splattering. This will then be added in successive small portions to 0.5g diphenylamine. The solution will be dropped (one drop only) on to the test sample using a pipette.

Persons at risk:
Students, staff and visitors

Summary of Control Measures				
Assessment of the risks from exposure to substances involved in this procedure (include any existing control measures already in place)	Minimal quantities of chemicals to be handled and used. The solution will be made up and used within a fume cupboard to avoid possible inhalation. A dust mask will be worn in addition to prevent inhalation of diphenylamine. Contact with skin will be avoided by use of PPE (nitrile gloves, lab coat, eyewear with side shield and closed toe shoes). The fume cupboard will also prevent spills from splashing on to the face. To avoid a violent reaction, the sulphuric acid will be added to the water and not vice versa.			
Risk Rating (Before Control)	High	Medium	Low	
Procedural Controls (e.g. lone working, hygiene)	• No food or drink in workroom. • Hair to be tied back. • No loose clothing, jewellery or lanyards.			
Engineering Controls (e.g. fume cupboard)	Solution to be prepared and used in the fume cupboard.			
PPE Requirements (Please give details) **Face fit testing required	**Dust Mask****	X Dust mask	**Gloves**	X Nitrile (diphenylamine break through time 480 mins)
	Respirator**		**Footwear**	X Closed toe shoes
	Eye Protection	X Glasses with side shield	**Protective Clothing**	X Cotton lab coat with sleeves unrolled
	Face Shield		**Other (Specify)**	
Instruction and Training	Knowledge of procedure through CCI instructions and reviewed with supervisor			
Supervision Required?	Yes, by supervisor.			
Other safety precautions: (Including specialist first aid requirements)	• Seek emergency medical help. • If inhaled move into fresh air. • In case of skin contact with diphenylamine, wash off with polyethylene glycol and then plenty of water. • In case of skin contact with sulphuric acid, remove all contaminated clothing and wash off with soap and plenty of water. • In case of eye contact rinse thoroughly with water for at least 15 minutes. • If swallowed do not induce vomiting. Rinse mouth with water and call a poison centre.			
New Risk Rating	High	Medium	Low	
Supporting Information Checklist (Include details for each where relevant)				
Waste Disposal	• Leftover solution to be stored for future use in locked acids/corrosives cupboard. • Very small quantities, i.e. left on glassware, to be diluted before disposed down the sink.			
Emergency Procedures (including spill / leak control)	• Use spill kit in chem lab 310 to mop up any spills – do not use water. • Broken glassware to be disposed of in the broken glassware container in chem lab 310.			
Atmospheric Monitoring	N/A			
Health Surveillance	N/A			
Supporting Risk Assessments (Please attach where relevant)	**Biological** N/A	**DSEAR** N/A	**Radiation** N/A	
Assessment Details				

Assessed By: Kim Tourret	**Date:** 13/06/18
Approved By: Karen Thompson	**Date:** 13/06/18
Date of next review: June 2020	
Description of Activity (Continuation sheet)	
Continuation sheet number:	

CoSHH Assessment Acknowledgement

By signing this document I acknowledge that I have read and understood the attached CoSHH assessment and have familiarised myself with the safety control measures and protective equipment necessary to carry out the task safely. I hereby agree to follow the safe system of work required and implement the required safety procedures fully.

Full Name	Signature	Date Completed

University of Glasgow — CoSHH Assessment

Assessment Title: Dissertation research project – Solubility testing
Assessment Reference Number: R52/C2
School / Service / Location: CTCTAH, Level 3 Robertson Building
Safety Coordinator: Karen Thompson

Details of Hazardous Substances (Please attach safety datasheets where available)

Name of Substance (Include all substances used or produced)	Quantity kg / g / ml	Physical Form	GHS Hazard Classification (Tick all that apply)								
1. Stoddards solvent/white spirit	<10mls	Liquid		X			X			X	X
2. Toluene	<10mls	Liquid		X			X			X	
3. Xylene	<10mls	Liquid		X			X			X	
4. Ethyl acetate	<10mls	Liquid		X			X				
5. Acetone	<10mls	Liquid		X			X				
6. Industrial denatured alcohol	<10mls	Liquid		X			X			X	
7. Isopropanol	<10mls	Liquid		X			X				
8. Pentan-1-ol (n-amyl alcohol)	<10mls	Liquid		X			X				
9. Benzyl alcohol	<10mls	Liquid					X				

Special Hazards (*Separate risk assessment may be required)

Carcinogenic Substance	Details:	Skin Sensitiser	Details:	Respiratory Sensitiser	Details:
Biological Material*	Details:	Radioactive Substances*	Details:	Explosive Atmosphere*	Details:

Further Details / Other Special Hazards: Majority of chemicals are irritants and flammable in use.

Exposure to Hazardous Substances

Substance	Possible Exposure Route (Please tick)					Workplace Exposure Limits	
	Inhalation	Ingestion	Skin	Injection	Other (State)	8h TWA	15min STEL
1. Stoddard solvent	X	X	X			N/A	N/A
2. Toluene	X	X	X		May be fatal if swallowed	50ppm	100ppm
3. Xylene	X	X	X		May be fatal if swallowed	50ppm	100ppm
4. Ethyl acetate	X	X	X			200ppm	400ppm
5. Acetone	X	X	X			500ppm	1500ppm
6. IDA – ethanol	X	X	X		May cause damage to organs	1000ppm	3000ppm
IDA – methanol	X	X	X		May cause damage to organs	200ppm	250ppm
7. Isopropanol	X	X	X			400ppm	500ppm

8. Pentan-1-ol	X	X	X			N/A	N/A
9. Benzyl alcohol	X	X	X			N/A	N/A

Description of Activity (Continue on a separate sheet if required)	
Solubility testing of an adhesive. Samples will be placed on glass slides and observed with a microscope as single drops of each chemical are dropped with a pipette on to them to test the solubility.	
Persons at risk: Students, staff and visitors	
Summary of Control Measures	
Assessment of the risks from exposure to substances involved in this procedure (include any existing control measures already in place)	Minimal quantities of each chemical to be handled and used. Contact with skin to be prevented with appropriate PPE (lab coat, nitrile gloves, eyewear with side shield and closed toe shoes). Inhalation of substances to be prevented by working under Nederman hood extraction. Ensure that there are no heat, flame, sparks and other ignitions sources as majority of substances are flammable.
Risk Rating (Before Control)	High / **Medium** / Low
Procedural Controls (e.g. lone working, hygiene)	• No food or drink in workroom. • Hair to be tied back. • No loose clothing, jewellery or lanyards.
Engineering Controls (e.g. fume cupboard)	Testing to be undertaken under a Nederman hood extractor.

PPE Requirements (Please give details)

**Face fit testing required

Dust Mask**		**Gloves**	X Nitrile
Respirator**		**Footwear**	X Closed toe shoes
Eye Protection	X Glasses with side shield	**Protective Clothing**	X Cotton labcoat with sleeves unrolled
Face Shield		**Other (Specify)**	

Instruction and Training	Knowledge of solvent procedures as explained by Karen Thompson, tutor.
Supervision Required?	Yes, by supervisor.
Other safety precautions: (Including specialist first aid requirements)	• Seek medical advice. • If inhaled move into fresh air. • In case of skin contact wash off immediately. • In case of eye contact rinse thoroughly with water. • If swallowed do not induce vomiting.
New Risk Rating	High / Medium / **Low**
Supporting Information Checklist (Include details for each where relevant)	
Waste Disposal	Disposal in non-chlorinated waste container in fume cupboard. Waste container to be retained for disposal via an approved contractor. Log use and disposal of IDA on sheets in chem lab 310.
Emergency Procedures (including spill / leak control)	• Mop up spills using paper towels and allow solvent to evaporate in fume hood in chem lab 310. • Broken glassware to be disposed of in the broken glassware container in chem lab 310.
Atmospheric Monitoring	N/A
Health Surveillance	N/A

Supporting Risk Assessments (Please attach where relevant)	Biological N/A	DSEAR N/A	Radiation N/A

Assessment Details	
Assessed By: Kim Tourret	**Date:** 13/06/18
Approved By: Karen Thompson	**Date:** 13/06/18
Date of next review: June 2020	

Description of Activity (Continuation sheet)
Continuation sheet number:

CoSHH Assessment Acknowledgement

By signing this document I acknowledge that I have read and understood the attached CoSHH assessment and have familiarised myself with the safety control measures and protective equipment necessary to carry out the task safely. I hereby agree to follow the safe system of work required and implement the required safety procedures fully.

Full Name	Signature	Date Completed

University of Glasgow — CoSHH Assessment

Assessment Title: Dissertation research project – Adhesive removal testing

Assessment Reference Number: R52/C3

School / Service / Location: CTCTAH, Level 3 Robertson Building

Safety Coordinator: Karen Thompson

Details of Hazardous Substances (Please attach safety datasheets where available)

Name of Substance (Include all substances used or produced)	Quantity kg / g / ml	Physical Form	GHS Hazard Classification (Tick all that apply)								
1. Ethyl acetate	<50mls	Liquid	-	X	-	-	X	-	-	-	-
2. Acetone	<50mls	Liquid	-	X	-	-	X	-	-	-	-
3. Industrial denatured alcohol	<50mls	Liquid	-	X	-	-	X	-	-	X	-
4. Sepiolite	<100g	Powder	-	-	-	-	-	-	-	-	-
5. Agarose	<100g	Powder	-	-	-	-	-	-	-	-	-

Special Hazards (*Separate risk assessment may be required)

Carcinogenic Substance	Details:	Skin Sensitiser	Details:	Respiratory Sensitiser	Details:
Biological Material*	Details:	Radioactive Substances*	Details:	Explosive Atmosphere*	Details:

Further Details / Other Special Hazards: Majority of chemicals are irritants and flammable in use.

Exposure to Hazardous Substances

Substance	Possible Exposure Route (Please tick)					Workplace Exposure Limits	
	Inhalation	Ingestion	Skin	Injection	Other (State)	8h TWA	15min STEL
1. Ethyl acetate	X	X	X	-	-	200ppm	400ppm
2. Acetone	X	X	X	-	-	500ppm	1500ppm
3. IDA – ethanol	X	X	X	-	May cause damage to organs	1000ppm	3000ppm
IDA – methanol	X	X	X	-	May cause damage to organs	200ppm	250ppm
4. Sepiolite	-	-	-	-	-	-	-
5. Agarose	-	-	-	-	-	-	-

Silk patchwork mock-ups will be coated with commercially available cellulose nitrate adhesive. Methods for removing the adhesive from the mock-ups will be tested. Methods include using various poultices, dropping solvent on to the mock-ups on a suction table, and immersion of the mock-ups in solvent.

Persons at risk:
Students, staff and visitors

Summary of Control Measures

Assessment of the risks from exposure to substances involved in this procedure (include any existing control measures already in place)	Minimal quantities of each chemical to be handled and used. Contact with skin to be prevented with appropriate PPE (lab coat, nitrile gloves, eyewear with side shield and closed toe shoes). Inhalation of substances to be prevented by working under Nederman hood extraction. Ensure that there are no heat, flame, sparks and other ignitions sources as majority of substances are flammable.

Risk Rating (Before Control)	**High**	**Medium**	**Low**
Procedural Controls (e.g. lone working, hygiene)	• No food or drink in workroom. • Hair to be tied back. • No loose clothing, jewellery or lanyards.		
Engineering Controls (e.g. fume cupboard)	Testing to be undertaken under a Nederman hood extractor or in the fume cupboard.		

PPE Requirements (Please give details) **Face fit testing required				
	Dust Mask**	Half mask disposable P3 dust mask when handling powders	**Gloves**	X Nitrile
	Respirator**		**Footwear**	X Closed toe shoes
	Eye Protection	X Glasses with side shield	**Protective Clothing**	X Cotton labcoat with sleeves unrolled
	Face Shield		**Other (Specify)**	

Instruction and Training	Knowledge of solvent procedures as explained by Karen Thompson, tutor.		
Supervision Required?	Yes, by supervisor.		
Other safety precautions: (Including specialist first aid requirements)	• Seek medical advice. • If inhaled move into fresh air. • In case of skin contact wash off immediately. • In case of eye contact rinse thoroughly with water. • If swallowed do not induce vomiting.		
New Risk Rating	**High**	**Medium**	**Low**

Supporting Information Checklist (Include details for each where relevant)

Waste Disposal	Disposal in non-chlorinated waste container in fume cupboard. Waste container to be retained for disposal via an approved contractor. Log use and disposal of IDA on sheets in chem lab 310.		
Emergency Procedures (including spill / leak control)	• Mop up spills using paper towels and allow solvent to evaporate in fume hood in chem lab 310. • Broken glassware to be disposed of in the broken glassware container in chem lab 310.		
Atmospheric Monitoring	N/A		
Health Surveillance	N/A		
Supporting Risk Assessments (Please attach where relevant)	**Biological** N/A	**DSEAR** N/A	**Radiation** N/A

Assessment Details

Assessed By: Kim Tourret	**Date:** 02/07/18
Approved By: Karen Thompson	**Date:** 04/07/18
Date of next review: July 2020	

Description of Activity (Continuation sheet)

Continuation sheet number:

CoSHH Assessment Acknowledgement

By signing this document I acknowledge that I have read and understood the attached CoSHH assessment and have familiarised myself with the safety control measures and protective equipment necessary to carry out the task safely. I hereby agree to follow the safe system of work required and implement the required safety procedures fully.

Full Name	Signature	Date Completed