STARCH AND OTHER CARBOHYDRATE ADHESIVES FOR USE IN TEXTILE CONSERVATION

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Edited by Pippa Cruickshank
and Zenzie Tinker

FOREWORD

The subject of the second Adhesives Forum was suggested after the formation of the Adhesives Group within the UKIC Textile Section in mid 1993. The group was established to try and disseminate more information about the choice of adhesives available to the textile conservation profession and to attempt to examine these materials and application techniques in depth.

The papers and poster texts that follow in this publication were presented at the one day meeting, 'Starch and other carbohydrate adhesives for use in textile conservation', held on 2nd November 1994 at the Museum of London, by the Adhesives Group.

The demand for an opportunity to discuss starch pastes and other carbohydrate adhesives reflects a huge interest in and possibly an insecurity about using these adhesives by textile conservators. There has been a long tradition of using starch pastes in conservation, particularly amongst paper conservators, but do these techniques necessarily transfer readily to textile conservation? Many of the papers present a persuasive argument that they do. Reversibility is often assumed with this group of adhesives but in Vincent Daniels' key paper, 'Starch Pastes', the question of true reversibility is raised and he asks whether, "starch paste would be considered as a conservation adhesive if it had been a modern synthetic material rather than a traditional natural one".

The papers and posters reflect not only the wide range of objects being treated with starch adhesives but also the great number of different starches in use and the even greater variations in method and application techniques being employed. The other adhesives represented combine to provide a fairly comprehensive body of work on the carbohydrate adhesives currently in use in textile conservation.

We are delighted to publish the full texts of the posters alongside the papers. Posters often provide real practical help with conservation problems and are sometimes missed or not read with the full attention they deserve in the crush of a conference coffee break. The annotated bibliography, we hope, will provide useful, additional reference material on the subject.

The editors would like to thank all those involved especially the authors of the papers and posters, Jenny Band who so successfully chaired the day's presentations and discussions and the one hundred delegates who attended.

The combined effort of many people made the Forum and this publication possible: the core team from the Adhesives Group - including Pippa Cruickshank, Janet Farnsworth and Kate Stockwell; staff of the Museum of London, particularly Frances Hartog and Barbara Heiberger; and Jane Jeffery of the Textile Conservation Centre.

Thank you to all.

Zenzie Tinker
Chair
Adhesives Group

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CELLULOSE ETHERS FOR TEXTILE CONSERVATION

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Introduction

Cellulose ethers have been used as adhesives, sizing agents and consolidants in paper conservation for around twenty years. To date, however, there is little published information concerning the applications of cellulose ethers to the conservation of textiles. Commercial literature suggests that cellulose ethers are sufficiently stable to find use as thickeners, stabilising agents, binders and film-formers in the cosmetic, food, pharmaceutical and chemical industries. However, few studies have concerned their suitability as conservation materials.

Adhesives suitable for use in textile conservation should have the following properties:

- an ability to wet and adhere strongly to their intended substrates;
- good reversibility, since future conservation treatments may require the removal of old repairs;
- stable chemical properties on ageing;
- stable mechanical properties on ageing; these should be compatible with those of the textile to be treated.

The purpose of this paper is to outline the manufacture and structures of the cellulose ethers most commonly used in conservation. The results of an investigation into the stability of cellulose ethers for use as conservation materials recently completed at the British Museum will be presented. In the light of the findings of this and previous research, the suitability of cellulose ethers as adhesives for textiles will be discussed.

Manufacture of Cellulose Ethers

There are many possible variations in the process of making cellulose ethers. The most common commercial procedure involves treating purified cellulose, derived from wood-pulp, cotton linters or related scrap materials, with sodium hydroxide solution. The product of this reaction is treated with an etherifying agent such as an alkyl chloride; the alkali catalyses the reaction and removes hydrogen chloride.

Figure 1: *Outline of chemical reactions involved in the synthesis of cellulose ethers. Cellulose is represented as Cell-OH in this scheme*

Cell-OH + NaOH ---> Cell-ONa + H_2O
alkali cellulose

Cell-ONa + $ClCH_3$ ---> Cell-O-CH_3 + NaCl
cellulose ether

Selection of suitable etherifying agents controls the chemical structure of the product. Methyl chloride is used to manufacture methyl cellulose, ethylene oxide for hydroxyethyl cellulose, propylene oxide for hydroxypropyl cellulose and chloroacetic acid for carboxymethyl cellulose.[1] Unlike the others, carboxymethyl cellulose (CMC) is always sold as the ionic sodium salt. Excess alkali is neutralised with an acid and the sodium chloride, produced as a by-product of the etherification reaction, is removed.

Structure of Cellulose Ethers

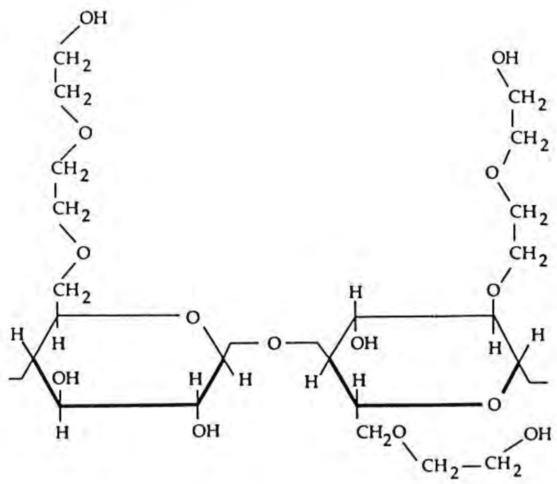
When cellulose is etherified, the hydroxyl groups are substituted by the etherifying agent. The average number of hydroxyls substituted per anhydroglucose unit of cellulose is known as the degree of substitution (DS) (Figure 2). The maximum DS is three. Substitution rarely takes place at one particular hydroxyl group in the anhydroglucose unit, but may take place at all three to different extents.[2] Physical properties of the cellulose ether are largely determined by the DS as well as by the chain length of the polymer.[3]

Figure 2: *Idealised unit structure for hydroxyethyl cellulose. In this diagram showing two anhydroglucose units, three of the six hydroxyl groups are etherified.*

DS = 1.5

Five molecules of ethylene oxide have been substituted into the two anhydroglucose units.

MS = 2.5



Etherifying agents introduce a new hydroxyl group which can further react with the agent. As a result, the total number of alkylene oxide molecules that react with each anhydroglucose unit is known as molecular substitution (MS).

Degradation of Cellulose Ethers
Technical data sheets supplied by manufacturers suggest that cellulose ethers are vulnerable to degradation by heat, light and biological agents when used for industrial applications.[4] If cellulose ethers or their solutions are used at temperatures above 50°C, manufacturers recommend the incorporation of antioxidants and stabilisers. If films of cellulose ethers are exposed outdoors for long periods, the commercial literature recommends the inclusion of an ultraviolet light absorber. When large quantities of aqueous solutions are stored for longer than a few days, they are vulnerable to biodeterioration and should be treated accordingly. However, cellulose ethers in conservation are unlikely to be exposed to such severe conditions as those in industry.

The rate of degradation of cellulose ethers in aqueous solution is also dependent on the pH. All cellulose ether solutions tend to depolymerize in the presence of both acid and alkali. However, with the exception of CMC, all solutions of cellulose ethers show a relatively stable molecular weight over the range of pH 3 to 11.

CMC, having ionic properties, behaves differently to other cellulose ethers. When a CMC solution is acidified with strong mineral acids, the sodium salt is converted to the free acid form which is insoluble and precipitates. This precipitation may occur at pH of 2 to 3, depending on the acid used and the DS of the CMC. Such low pH values are unlikely to be encountered in textile conservation.

Stability of Cellulose Ethers as Conservation Materials
Several detailed evaluations of cellulose ethers for use in conservation have been conducted in recent years. These have concerned the chemical stability of cellulose ethers after accelerated ageing. The conditions used were severe; between 90° and 110°C for thermal ageing. Calculations made using the Arrhenius equation suggest that ageing at 70°C represents better the required useful lifetime (50 years) of a material than ageing at higher temperatures for a shorter period of time and this is the regimen used at the British Museum.[5] Little research has been published concerning the effect of ageing on the mechanical properties of cellulose ethers. The purpose of a recent project conducted at the British Museum was to compare the effects of ageing on the chemical and mechanical properties for several cellulose ethers commonly used as conservation materials.

The materials evaluated were Blanose 7MC (sodium carboxymethyl cellulose), Culminal (methyl cellulose), Klucel G (hydroxypropyl cellulose with an average molecular weight of approximately 370,000) and Klucel L (hydroxypropyl cellulose with an average molecular weight of approximately 95,000). Aqueous solutions (5% w/v) were prepared of all the cellulose ethers tested. Klucels G and L required several hours of continuous stirring to form clear solutions.

Cellulose ethers were evaluated both as free films and when applied to a standard, cotton cellulose paper with no binders for fillers. Free films were cast onto a flat sheet of polythene using a wirewound bar coater to produce films with wet film thicknesses of 50 microns. Films were allowed to dry before peeling from their polythene backing. Solutions of all materials were applied to the experimental cellulose substrate using a wirewound bar coater. Appearance, linear shrinkage, bonding strength and reversibility were measured and compared before and after ageing.

Accelerated Ageing
Since we do not have the luxury of time, the ageing process needs to be accelerated so that any changes in the properties of a material may be detected within a reasonable time span. This is achieved in practice by increasing the energy of the system using heat and light in order to speed any reactions which may occur with time. Prepared films of cellulose ethers were heat-aged in stoppered Quickfit tubes in a convection oven at between 70 ± 1°C for 28 days and examined weekly for changes in their properties. The purpose of light ageing is to reproduce the behaviour of a material which is exposed to daylight once it has been applied to the objects. A Microscal light fastness tester fitted with a 500 watt phosphor-coated bulb was used to light-age samples of cellulose ethers. The lamp provided a similar distribution of wavelengths to daylight, but continuously and at a high illuminance.

Colour Measurement
Films of Culminal appeared slightly cloudy on drying, but all other cellulose ethers produced transparent, colourless films. Discolouration of aged and unaged samples were monitored by eye and reflectance spectophotometry. UV/visible reflectance spectra of films were run between 760nm and 380nm using a Perkin-Elmer UV/visible 551S spectrophotometer fitted with an integrating sphere. CIELab colour co-ordinates were calculated from the spectra and used to determine the colour change (ΔE) caused by exposure to the

accelerated ageing regimes. Experience has shown that a change in ▲E greater than around one unit is detectable by eye. The results show that little visible change in colour took place on ageing in any of the prepared samples examined with the exception of free films of Klucel G. The high molecular weight hydroxypropyl cellulose yellowed slightly after 21 days' exposure to the light fastness tester.

Table 1: *Colour differences of cellulose ether films on ageing*

	Colour Difference (▲E)	
Materials	Heat Aged	Light Aged
Blanose 7MC	1.04	0.97
Culminal	0.95	0.83
Klucel G	1.76	3.26
Klucel L	1.30	1.28

Linear Shrinkage

Linear shrinkage may be caused by the removal of solvent from a drying film or by a change in density or orientation of polymer molecules. It is important to be aware of the magnitude of shrinkage before applying a resin to an object since it indicates the magnitude of forces set up when the resin is applied to a surface.

A flat glass plate was covered with polythene sheeting; four crosses, each at the corner of a 20mm square, were marked on the surface using a fine-tipped ballpoint pen. The distances between the centres of the crosses were measured using callipers. Films of the prepared solutions of cellulose ethers were cast on the polythene using a 50-micron wirewound bar coater. When dry, the film was peeled from the plate, the distances between the crosses, which had transferred from the polythene, were remeasured and the mean percentage shrinkage was calculated. Test pieces were heat and light aged as previously described and the procedure repeated.

Culminal (methyl cellulose) showed the greatest shrinkage on drying (5 ± 1%) but did not shrink measurably during ageing. All other cellulose ether films shrank by between 2 and 3% on drying and remained dimensionally stable on ageing.

Tensile Testing of Adhesive Bonds

Repairs to textiles most often involve either adhesion of a loose piece to the main body, or adhesion of a reinforcement material to the object. In both cases, the bond may be subject to both shear and tensile forces and is best represented as a lap join in which the two adherends overlap. In order to replicate the types of repair used in textile conservation while minimising the additional variability introduced by the weave type, Whatman Number 1 filter paper, a pure cellulose material, was used to prepare test pieces.

Pieces of filter paper (10 samples, each 2.0cm x 5.5cm) were cut and the prepared solutions of cellulose ethers were applied to one of the shortest edges to a depth of 0.5cm. Joins were assembled from two pieces and held in position between glass plates for 48 hours prior to undergoing accelerated ageing. Joins were conditioned at 50 ± 2% relative humidity and 20 ± 1 °C (the standard conditions for testing of paper) for three hours prior to tensile testing. A JJ Lloyd Tensile Testing Machine T5003 fitted with a 500N load cell was used to stress the test pieces to failure.

The stress required to break the join was read directly from the trace produced by the tensile tester and the surface area of the join was measured. The mean bond strength was calculated from the expression:

$$\text{Bond Strength} = \frac{\text{Breaking Stress (Newtons)}}{\text{Surface Area of Bond (m}^2\text{)}}$$

Aqueous solutions of both Klucels bonded weakly to cellulose and failed readily on tensile testing; bonds made with the hydroxypropyl celluloses disintegrated on ageing (see Table 2 overleaf). Culminal formed stronger bonds with the test substrate than the other cellulose ethers examined; bond strength was largely retained on ageing. In order to compare the bond strengths of cellulose ethers with that of other natural adhesives commonly used in the conservation of organic materials, the values for gluten-free wheat, rice starch and gelatine, evaluated under the same conditions and at the same time have been included in the results. It may be concluded that cellulose ethers form weaker bonds than other natural adhesives, but that their bond strength is better retained on ageing.

Reversibility

From manufacturers' literature, it seems that the solubility of cellulose ethers is related to the DS of the polymer. As the DS increases, cellulose ethers gradually pass through a stage of solubility in dilute alkali (DS up to around 1.0), then a water-soluble stage (DS 1.0 to 2.3), and finally an organic-soluble stage (DS 2.3 to 3.0). This is because, at low degrees of substitution, the replacement of some of the hydroxyl groups by ether groups reduces the hydrogen bonding across the

Table 2: Breaking Stress of Lap Joins between Cellulose Ethers and Whatman No. 1 Filter Paper

Material	Treatment	Mean breaking stress Nm^{-2} (x 10^4) units	Standard Deviation	Percentage loss in breaking stress on ageing (%)
Blanose 7MC	U	1.0	121.0	-
	L	0.8	152.0	1.0
	H	0.8	210.3	1.0
Culminal	U	1.5	77.2	-
	L	1.4	106.1	6.7
	H	1.3	125.0	13.3
Klucel G	U	0.04	173.5	-
	L	0.03	178.0	25.0
	H	0.03	164.6	25.0
Klucel L	U	0.04	135.4	-
	L	0.03	148.1	25.0
	H	0.03	156.4	25.0
Gluten-free wheat starch	U	2.4	219.6	-
	L	2.0	214.1	16.7
	H	1.8	219.7	25.0
Rice starch	U	2.0	82.2	-
	L	1.9	76.5	5.0
	H	1.6	93.4	20.0
Gelatine	U	4.9	65.7	-
	L	4.5	89.0	8.2
	H	3.7	97.2	24.5

Key: U = *Unaged*
L = *Light aged*
H = *Heat aged*

cellulose chains to such an extent that the material becomes soluble in water. Further replacement of hydroxyl groups by the less polar, hydrophobic, ether groups increases the resistance to water; fully etherified polymers are only soluble in non-polar solvents. In addition, the uniformity of substitution along the cellulose chain can have a major influence on solubility. Temperature also affects the solubility of some cellulose ether solutions, methyl cellulose in particular, causing them to flocculate on heating. This may be explained by the formation of additional hydrogen bonds.

Since little research has been published about the effects of ageing on reversibility, the subject was studied as part of the project conducted at the British Museum. Samples of aged and unaged films (0.1g) were accurately weighted into a sample tube and 1ml of the test solvent was added by pipette. Tubes were sealed and left for 24 hours. Any liquid was decanted and the tubes and any remaining residues dried to constant weight at 30°C. Distilled water at 20 ± 1°C, industrial methylated spirits and acetone were used as test liquids. The procedure was repeated to obtain triplicate results, and the percentage solubility was calculated from the expression:

$$\% \text{ Solubility} = 1 - \frac{\text{(Mass of residue after test[g])}}{\text{(Mass of initial sample [g])}} \times 100\%$$

Klucels were completely soluble in water, industrial methylated spirits and acetone, and retained their solubility on ageing. All other cellulose ethers tested were only soluble in water but also showed good ageing properties. It may be concluded from this study that films of cellulose ethers will remain soluble for at least 50 years, the minimum required time for a conservation grade material. However, in the case of textile conservation, solubility of any adhesive is rarely the only factor associated with reversibility of a treatment. The fibrous structure of the substrate may complicate complete removal.

Conclusions

Cellulose ethers have a long history of use in paper conservation, but would also be suitable for conservation of cellulosic textiles. They are available as water or water- and organic solvent- soluble types. Cellulose ethers are available with a range of molecular weights which produce solutions with a variety of viscosities. The degree of substitution and molecular weights of cellulose ethers determine their chemical and mechanical properties.

Methyl, carboxymethyl, and low molecular weight hydroxypropyl celluloses show good resistance to discolouration on ageing. High molecular weight hydroxypropyl cellulose is less colour-stable when exposed to light, so would be unsuitable as a surface treatment. Methyl cellulose and carboxymethyl cellulose form strong bonds with cellulosic substrates and retain their bond strengths better than other natural adhesives in common use for textile conservation. Hydroxypropyl celluloses form weaker bonds and may require more concentrated solutions than other cellulose ethers when used as adhesives; the bonds formed tended to fail on ageing. It should be noted that all aqueous solutions of cellulose ethers are susceptible to mould growth; for this reason only the quantity required for two days' work, particularly in warm workshops, should be prepared at one time. Solutions may be stored under refrigeration.

Health and Safety
Cellulose ethers are usually purchased in the form of fine powders. They present little risk to users but dust masks should be worn to avoid inhalation of the fine particles. When in aqueous solution, spillages should be dealt with promptly since such liquids may make floors slippery.

Acknowledgements
I would like to thank Vincent Daniels for his advice on the text of this paper and Andrew Oddy, Keeper of the Department of Conservation, for encouragement to publish.

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Materials and Suppliers
Cellulose ethers
Aqualon Ltd
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A CELLULOSE CONSOLIDANT FOR CELLULOSICS

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Introduction

Cellulosic fibre material of bast, leaf, seed or root origin are degraded by almost every known physical, chemical and biological factor, resulting in embrittlement, discolouration, loss of strength etc.[1] Some fibre objects, such as initiation masks, were openly intended for use once before being discarded while other objects, such as fishing nets, may have been used extensively before becoming part of a collection. An object destined for storage in ideal conditions would not normally require the same treatment as an object that forms part of a study or loan collection, or open air or travelling exhibit.

Consolidants and Adhesives

A consolidant is a medium which can impregnate the material and impart strength by binding it together.[2] An ideal consolidant for cellulosic fibre materials[3] should:

- provide strength and in some cases flexibility to degraded and embrittled fibres;
- remain reversible and chemically stable over long periods;
- not change the colour, texture and appearance of the fibre material;
- have low viscosity to ensure good penetration and minimal shrinkage due to solvent loss;
- not swell the fibres.

Early consolidants

Formerly all that was required of a consolidant / adhesive was that it should hold the object together. Table 1 shows some of the types of adhesives used in the past which could penetrate the fibres to some extent and thus could be considered as consolidants. This list does not include the lubricants and humectants such as oils, lanolin and glycerol which prevent powdering and increase flexibility but do not in any way strengthen the structure.

Table 1: Natural adhesives

Plant origin	*Animal origin*	*Mineral origin*
Gums	Casein	Paraffin wax
Starches	Gelatin	Copal resin
Resins	Beeswax	Bitumen
Seaweed	Shellac	
Derivatives		
Proteins		

Museum collections, especially those in older museums, provide plenty of examples of consolidation with adhesives which are often difficult or even impossible to remove without damaging the object, even if one could identify the substance. Rixon[4] described simple identification tests for animal glues and gelatin, shellac and cellulose acetate and nitrate. Howie[5] compiled a very useful table showing the chronology of materials used for fossil consolidation from c.1800, many of which have also been used on fibrous organic objects.

In a six month period, the Textile Conservation Workshop of the National Museum of Denmark was presented with examples of archaeological cellulosic fibre textiles consolidated with shellac, string and knot samples coated with waterglass, and other materials impregnated with glycerol. In these cases, it proved impossible to remove the consolidant without severely damaging the objects and it was sometimes necessary to consolidate these 'consolidated' objects.

Modern consolidants

The fibre consolidants in current use are generally still dilute solutions of adhesives: acrylates, polyvinyl resins, waxes, eg. polyethylene glycols and cellulose derivatives.

Hydroxypropyl cellulose-Klucel is the most recent addition to this last group.

Table 2: Cellulose derivatives

Cellulose acetate		
Cellulose nitrate		
Methyl cellulose	-	*Methocel*
Sodium carboxymethyl cellulose	-	*Cellofas, CMC*
Methyl hydroxyethyl cellulose	-	*Tylose*
Ethyl hydroxyethyl cellulose	-	*Modocol E*
Hydroxy ethyl cellulose	-	*Natrosol*
Hydroxy propyl cellulose	-	*Klucel*

Hydroxypropyl cellulose (HPC) is produced by reacting alkali cellulose with propylene oxide at elevated temperatures and pressures, to give a highly substituted cellulose chain with secondary hydroxyls as the main reactive groups.[6]

Klucel

Table 3: Solvents for Klucel

A: Clear and Smooth	
Water	Dioxane
Methyl alcohol	Dimethyl sulfoxide
Ethyl alcohol	Dimethyl formamide
Isopropyl alcohol (85%)	Ethylene chlorohydrin
Propylene glycol	Tetrahydrofuran
Methyl Cellosolve	Cyclohexanone
Cellosolve	t-Butanol:water (9:1)
Chloroform	Acetone:water (9:1)
Formic acid (88%)	Glycerin:water (3:7)
Acetic acid (glacial)	Benzene:methanol (1:1)
Pyridine	Toluene:ethanol (3:2)
Morpholine	Methylene chloride: methanol (9:1)
B: Moderately Granular and/or Hazy	
Tertiary butanol	Methylene chloride
Cyclohexanol	Butyl acetate
Acetone	Butyl ellosolve
Methyl ethyl ketone	Lactic acid
Methyl acetate	Naphtha:ethanol (1:1)
Isopropyl alcohol (99%)	Xylene:isopropyl alcohol (1:3)
C: Insoluble	
Aliphatic hydrocarbons	Methyl chloroform
Glycerin	Carbon tetrachloride
Benzene	Gasoline
Toluene	Kerosene
Xylene	Mineral oils
Dichlorobenzene	Soybean oil
Trichloroethylene	Linseed oil

Solvents were tested using Klucel G at 2% solids concentration by weight
All ratios indicated in this table are on a by-weight basis.

Properties of Klucel

- Soluble in water below 38°C, many polar organic solvents and solvent combinations (see Table 1). Insoluble in water above 45°C;
- High surface activity, low surface tension;
- Compatible with many water soluble polymers, eg. polythene glycols (PEG forms);
- Very flexible, clear and colourless film;
- Plasticisers, eg. PEG, can be added;
- Thermosoftening temperature of 130°C so can be heat sealed;
- Wide range of viscosities available;
- Low water affinity, so non-tacky at high humidity;
- Good biodegradation resistance (due to high substitution in the polymer);
- Also compatible with various biocides;
- Non-toxic (used in pharmaceutical food industries).

Conservation uses of Klucel

In the last thirteen years it has proved a useful fibre consolidant for paper[7] and other dry cellulosic fibres[8] and in the freeze-drying of waterlogged material such as rope.[9] It has good stability to both heat and light ageing[7,10] and is soluble in a wide range of solvents[6] (Table 3) which increases its range of applications and chances of future reversibility. It is available in a variety of grades, 'G' being used in paper conservation and 'E' being the most suitable for fibre consolidation because of its low viscosity and non-darkening with ageing. Its use will be further illustrated in the following section.

Case Histories

The following brief case histories illustrate typical uses of hydroxypropyl cellulose for fibre consolidation.

Oceanic modesty apron

After eighty years nailed up on open display in a seaside museum, this 'modesty apron' was very fragile, brittle and dusty. It was laid on a frame and washed by rocking gently in demineralised water. Excess water was blotted off and the frame lowered into a 3% solution of Klucel E in demineralised water. After twenty minutes the frame was taken out and the apron allowed to dry while still on the frame. The object itself was not touched at all during treatment. It is now strong enough to be displayed again, hopefully under better conditions.

String-bound straw beehive

This beehive was from an open air museum in West Jutland. Due to a flood, it was wet, mouldy, misshapen and very dirty. After drying, loose debris was removed using a vacuum cleaner and the beehive washed in an ethanol / isopropanol mixture with a soft brush. When half-dry, the beehive was impregnated with a 3% solution of Klucel E in isopropanol / demineralised water 9:1 and re-shaped using elastic bandage. When dry, loose pieces were adhered with a 7% aqueous solution of Klucel E.

Net from Greenland

Fibre analysis shows this net, supposedly from Greenland, to be made of Phoric tenax - New Zealand flax. The stiff and brittle net was put into a humidity chamber overnight and then carefully unfolded. It was sprayed with an aqueous solution containing 1.5% Klucel E and 0.5% polyethylene glycol 550. The net is now strong and flexible enough to be handled.

Waterlogged rope

In 1811, HMS St. George sank off the west coast of Denmark. Objects recovered from the wreck in 1992/93 include large quantities of wood, leather, ceramic and metal items. Most of this material was in quite good condition but the textiles were in very poor condition. Large amounts of rope were also recovered.

A leather bucket used for hauling sea water on board was found with its coiled rope inside. The rope was put into a net support, pre-treated with diNa EDTA, rinsed, impregnated with a solution of 2% Klucel E (hydroxypropylcellulose) and 1% PEG400 (polyethylene glycol) and freeze-dried. It was put into a humidity chamber overnight and then re-coiled prior to replacing it in its bucket which had also been freeze-dried.

NOTE: Most of this work was undertaken (and published) more than ten years ago. To date, all objects treated are reportedly stable.

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A KLUCEL TREATMENT FOR SILK FIBRES ON TASSELS AND TRIMMINGS

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Introduction
The work described in this paper took place in the context of a project of conservation and display of a large collection of tassels and trimmings from Castle Coole, a National Trust property in Northern Ireland. Work was carried out in 1987-88 at the Levy Textile Workroom of The National Trust where I was Assistant Textile Conservator at the time.

The project was the subject of a paper presented at the Conference on the Conservation of Furnishing Textiles at The Burrell Collection, Glasgow, in March 1990 and is published in full in the postprints.[1]

This short paper concentrates on one aspect, the application of Klucel G, dissolved in acetone, in the treatment of silk tassels and trimmings.

The Conservation Problem
The tassels and trimmings comprised a wooden base of several elements, closely covered with laid wool, silk and sometimes cotton threads or unspun fibres. They were further embellished with a variety of decorative details.

Their condition varied and the following forms of damage had occurred:

- surface and ingrained soiling;
- light damage causing deterioration and loss of silk fibres in particular;
- mechanical damage, mainly woodworm, which affected many of the wooden moulds; the laid covering threads were also damaged by the insects as they emerged.

These combined factors resulted in many cases of deteriorated, broken and lifting laid threads, often revealing the bare wood.

The construction of the objects meant that there were few treatment options. The lifting threads and fibres, originally stretched over the wooden base and secured at the core, now had to be attached to the bare wood. The use of an adhesive was often the preferred method.

The Choice of Adhesive: Klucel G
Klucel G, hydroxypropyl cellulose, is a non-ionic cellulose ether. It comes as a white powder and dissolves in water as well as in certain organic solvents, such as Industrial Methylated Spirits (IMS) and acetone.[2]

Klucel G was chosen because it was considered safe for conservation use, according to the manufacturer[2] not prone to cross-linking or yellowing, although the latter has since been disputed.[3] It remains soluble in water, IMS and acetone for a long time, making the treatment relatively reversible.

It was easy to apply, quick to hold down silk fibres and it seemed sympathetic to the materials of the objects.

The main advantage was that it could be used in solution with acetone.

This was necessary to reduce the risk of darkening of the textile fibres. Many of the objects were quite dirty with ingrained soiling which could not be fully removed. In contact with water severe darkening would have occurred.

The Treatment
Klucel G was dissolved in acetone in a 4% solution to form a thick gel. To prevent rapid evaporation of the acetone, the adhesive was kept in a closed container, taking out small working amounts at a time. When using Klucel in acetone work took place in a fume cupboard.

The tassels and trimmings were surface cleaned by vacuum suction. Attempts to clean the fibres further were largely unsuccessful. The exposed wooden surfaces were also cleaned as much as possible, sometimes using a cotton wool swab and IMS or white spirit. The use of water was not safe in most cases.

After cleaning, the broken laid threads were disentangled where necessary.

Klucel was applied to the wooden base with a fine brush and allowed to be absorbed for a few moments. If necessary a little more adhesive was applied and the fibres were stroked down onto this, using a fine, pointed, stainless steel tool.

Adhesive was not applied directly to the fibres to avoid unnecessary wetting.

Conclusion
The treatment was successful for most of the silk trimmings. However, a small risk of darkening of soiled fibres remained, and high-risk, severely soiled objects were treated with a different adhesive method. Klucel was also not strong enough to adhere wool threads which had retained their bounce, and these were treated in different ways too.

I suspect that this treatment would not withstand much wear or abrasion, but it was found sufficient for display in a controlled environment.

The long-term stability and effectiveness of hydroxypropylcellulose is under discussion. It was termed 'intermediate' by Feller and Wilt in their study for the Getty Conservation Institute in 1990.[3]

The conservator contemplating the use of Klucel G will have to take this point into account. Methylcellulose and carboxycellulose are more stable than Klucel, and the most stable of all cellulose ethers. However, as they do not dissolve in organic solvents, they lack the advantage of Klucel G that I found so useful in this case.

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STARCH ADHESIVES

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Introduction

For most conservators starch is wheat starch, a white powder which can be made into an adhesive for paper. Paste is prepared by heating starch in water. However, many different types of starch pastes are potentially available by the use of starches from various plants and different methods of preparation.

Starch with very few exceptions is only found in plants and is one of the most commonly occurring carbohydrates in nature. It is present in high concentrations in many seeds and tubers, and thus the sources for manufacturing starches are materials such as the seeds rice, wheat, barley and rye and the tubers potato and tapioca.

Starch is present in plants as granules often closely packed together but generally within a seed coat or skin and with some associated protein, mineral content and enzymes. Extraction processes generally involve a physical separation of the starch granules from the other materials. Wheat grain is ground into flour which usually contains protein and starch granules, the wheat germ and husk being removed in the milling. Starch is often extracted by a modification of the traditional process; kneading the flour into a dough under water separates the gluten protein from the starch. The gluten forms a sticky mass while the starch is dispersed as particles in the water forming a milky suspension which settles on standing depositing fairly pure starch. Flour with elastic gluten (hard flour) is easier to purify by this method than flour that produces a crumbly gluten (soft flour).

Starch granules vary in size and appearance. Potato produces large grains of 15 to 100 microns diameter. Wheat starch has particles which vary in size from 2 to 35 microns, whereas rye starch granules are small at 4-6 microns average diameter.

As starch is easily separated from grain and tubers it is reasonable to think that it was known to ancient man. The Roman Pliny[1] writing in the first century AD states that starch made from the finest wheaten flour, mixed with boiling water with a trace of vinegar was used for the manufacture of papyrus. Hunter[2] reports that at about 700 AD oriental papers started to be sized with starch and for the next 700 years starch was the main paper size used. Radley[3] has detected starch in many old oriental papers finding rice, wheat and barley starch. The use of starch for stiffening linen was first mentioned in 1390. Radley also says that the first use of large quantities of starch in England was for cosmetics in the form of coloured starches for the hair and skin. Red, yellow and purple starches were popular. Starch making was forbidden in 1610 as it was seen as a waste of flour; however, the trade was revived in 1622. Radley is of the opinion that the greatest use of starch in Britain prior to 1830 was as a hair powder.

The modern starch industry really dates from the discovery that starch can be modified by dry roasting it. The process not only meant that starch paste of a wide range of properties could be prepared but opened the way to the manufacture of 'British gum' and starch sugars. Nowadays 50% of world starch production is converted to glucose.

Starch is a natural polymer made from the monomer glucose. When the starch polymer is in a straight chain it is called amylose and when in a branched structure amylopectin. Recent research has revealed that amylopectin contains some phosphate groups in addition to the linked glucose monomer units.

Granules of starch are partially crystalline. The crystalline areas contain larger proportions of linear amylose than the non-crystalline (amorphous) regions as it is easier to arrange the regular amylose into crystals than the irregularly branching amylopectin. X-ray diffraction patterns obtained from starch can be used to study the extent and nature of the crystallinity. Starches differ from one another by the relative amounts of amylose and amylopectin, their molecular weights and the degree of branching in the amylopectin. Granules are coated with low molecular weight carbohydrates called pentosans, which will also affect the properties of the prepared starch paste.

When wheat starch is soaked in water, starch granules absorb some water into the amorphous regions and the granules expand slightly. On heating to 50°C the large granules start to swell; then at higher temperatures, the smaller ones. At 65°C the granules burst and rapid gelatinisation proceeds and at 70°C the granular structure and all the crystallinity has disappeared. At this stage the viscosity of the starch paste is high because of the crowding effect of the swollen granules which still retain some of their original shape. However, when a high shear is applied, eg. vigorous stirring, the paste thins.

On cooling the starch attempts to recrystallise due to the great potential for hydrogen bonding of the two starch components. The amylose can crystallise faster than the amylopectin. The process of recrystallisation is called retrogradation because the starch is attempting to revert to its original condition. The paste becomes white, less translucent, stiffer and less sticky. Retrogradation may be seen in just a few hours but may continue for several weeks. Studies are not generally continued beyond a few days as biodeterioration sets in.

The process of retrogradation is of considerable interest as it leads to textural changes in foods made with starch, eg. bread, soups, meat preparations etc. Retrogradation also plays a large part in the staling of bread.

Although most starches have about 15-20% amylose, plants can be hybridised to give starches with almost 100% amylopectin - these retrograde very slowly; such starches are called waxy. Starches with a high amylose content retrograde rapidly. Retrogradation also depends on molecular weight with medium molecular weights retrograding faster.

The temporal change of properties in starch past was first noted by Pliny[1] who says that starch paste for papyrus 'ought to be exactly a day old - no more nor yet less'.

The best known tests for the presence of starch is the reaction of iodine solution with starch (or dextrin) to give an intense blue/black colour. The reaction is complex and chemically interesting. Amylose is thought to be present in solution in a helix. Iodine reacts with amylose to give a blue product with the iodine atoms arranged in a linear fashion inside the starch helix. On the other hand amylopectin gives a red/violet colouration. High amylopectin starches are called 'red iodine starches'. Analysis of the visible light transmission spectrum of the colour formed is the basis for an analytical technique to determine the relative proportions of amylose and amylopectin in a starch. Retrogradation decreases the scope for iodine absorption as amylose becomes crystalline.

In Japan, starch pastes for scroll mounting are made from wheat starch. Some paste is used fresh but some may be left to age for up to ten years. The Japanese name for the aged paste is *furu-nori*. Such paste has been made at the British Museum and has been studied by Daniels.[4] Viscosity measurements indicated that some depolymerisation had taken place and that the starch was retrograded, however the ratio of amylose to amylopectin had not changed greatly. Some biodeterioration had taken place as the paste had gone through a stage where there was mould growth when the paste became mildly acidic, however, when diluted for use the acidity was negligible.

Biodeterioration

It has already been noted that raw starch contains enzymes. Once water is added to starch grains, biological activity starts, however the enzymes initially present are destroyed in the cooking. After standing for a few days starch pastes often develop mould growth. This is quite understandable as starch pastes are a good food source for a wide range of fungi and often contain some protein in addition to simple and complex sugars. Industrially, fungicides are often added but these often have little effect unless present in high concentrations. As starch retrogrades on standing, stored starch paste is not the same as the desired fresh product so there is often little point in attempting to prevent biodeterioration. As biodeterioration proceeds the starch becomes more acidic smelling of acetic or butyric acid. Radley[3] reports that *Aspergillus* and *Penicillium* fungi are usually predominant along with butyric acid producing bacilli. Enzymes released by the fungi depolymerise the starch which becomes progressively watery.

The vinegar smell often attracts *Drosophila* flies (Vinegar flies) which carry the eggs of eel worm (nematodes). The nematode which concerns us is the paste eel worm *Tubatrix aceti* and is the same as the vinegar eel worm although long thought to be a different species.[5] This nematode was often found in gone-off starch paste. While in Kyoto Miss Sydney Thomson found these nematodes in high concentrations in the top water above ageing starch paste. In Japan it was believed that these contributed to the quality of the end product.

Modified Starches

Starches may be modified before or while being made into paste (cooking stages. Heating dry starch often with a trace of acid produces a product which is soluble in cold water. The discovery of this phenomenon is alleged to have been brought about by accident after a fire in a starch warehouse. The product of roasting dry starch is called dextrin or British Gum. The adhesive can also be made using enzymatic hydrolysis using the enzyme amylase.

Oxidation of starch by, for example, hypochlorite bleach, yields a product which is relatively depolymerised with respect to the initial material. The treated starch has greater penetrating power and transparency.

Acid treatment has been used by Van Steene et al to produce a modified starch for conservators.[6] During heating in dilute hydrochloric acid the starch depolymerised to produce a low viscosity product with improved flexibility. This process is also employed industrially.

Starch may be modified to produce esters and ethers in much the same way as cellulose is treated to make cellulose derivatives, but the resulting starch products have so far found no use in conservation. Industrially they are frequently used in food. As the crystallinity of the starch is destroyed in the derivatisation process and does not return, the products are usually cold water soluble.

The conservator may find cold water starch pastes for sale. These are starches which have previously been made into pastes with or without some form of chemical modification and then dried. These products can then be reconstituted with cold water.

Reversibility

Starch has always enjoyed extensive use in conservation as it has been deemed to be a reversible adhesive. Certainly joins between paper made with starch pastes come apart when soaked in water. However, it is interesting to consider whether starch paste would be considered as a conservation adhesive if it had been a modern synthetic material rather than a traditional natural one.

Reversible adhesives dissolve in solvent which does not affect the substrate on which the adhesive is applied. However cold water has very little effect on old dried starch. It will part joined papers but inspection of the separated papers reveals that much of the starch remains behind. It is not until the water is heated almost to boiling point that the dried starch redissolves. A piece of dried starch paste can remain in cold water for over seven days without losing its shape so it cannot be said to be a reversible adhesive. However, pure starch adhesives are very stable and do not discolour so the consequences of leaving them behind are seldom a problem. When a non-aqueous solvent for starch is required N-methyl-2-pyrrolidine can be used. This has been shown to do little harm to a paper substrate[7]

Enzyme systems containing amylase are capable of breaking down both amylose and amylopectin. The enzymes are commercially extracted from bacteria eg. *bacillus* species and the porcine pancreas. Amylase is also present in human saliva. Amylase based systems (other than saliva) have been used for enhancing the reversibility of starch on paper.[8] Such systems usually include a pH buffer to optimise the effect of the enzyme.

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CONSERVATION OF A BARK CLOTH USING TAPIOCA STARCH

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Introduction
In summer 1991 a sheet of decorated bark cloth was brought to the Textile Conservation Centre to be conserved. Earlier on its owner had rescued it from a flea market where it was hanging nailed on the side of a lorry. The aim of the conservation was to stabilise the bark cloth in order to enable safe display in a domestic environment by an appropriate mounting system without forgetting the aesthetic appearance of the object.[1]

The manufacture of bark cloth was examined in detail since it is a more complex material in structure and composition than paper and textiles. A thorough understanding of the characteristics of bark cloth is required to enable the choice of suitable conservation materials and treatment. This paper discusses the reasons for the choice of contemporary bark cloth and tapioca starch to conserve the bark cloth.

Description
The bark cloth is ecru coloured. The central panel is decorated with geometric patterns and the borders are plain. It measures approximately 210cm x 140cm, and the width of the plain borders varies from 15cm to 40cm. The design is achieved by rubbing the cloth surface with reddish-brown pigments followed by over-painting with thick dark brown paint. This renders some extra thickness to the already coarse structure of the bark cloth.

Manufacture
The bark cloth is made of two layers of beaten inner bark of paper mulberry.[2] The two layers of bark cloth consist of several sheets of bark fibres, all aligned in the same direction in a single layer held together with a starch paste[3] used in the manufacture to form a single piece. On the front side the fibres are aligned horizontally when viewing the bark cloth upright. On the reverse side the fibres are aligned vertically. The layers on the border are not pasted together and therefore two separate layers can be distinguished. During the manufacturing process six holes on the reverse side were filled with bark cloth patches.

The bark cloth originates from Samoa.[4] The absence of felting during the manufacture, and rubbing and over-painting of a design instead of stencilling and printing distinguishes Samoan bark cloth from the others, particularly the Fijian ones, being coarser in structure. It is difficult to determine the age of the bark cloth exactly but it is probably from the end of the 19th century. It has been suggested[5] that it was made for the tourist trade. Its cleanness and lack of soot and lack of fold lines would support the theory.

Condition
The poor condition of the bark cloth is in proprotion to its structrual features, exacerbated by the former unsuitable handling and the environment. The bark cloth was creased and crumpled, and holes present in it are partly a structural feature due to the manufacturing technique, and partly caused by other forces. The border is badly damaged; the edges are ragged with several severe losses. Tears along the edge of the dark brown paint are due to the difference in thickness and texture of the surface decoration. Also acidic dyes used to decorate Samoan bark cloths can saturate the fibres and accelerate the degradation.[6] The dark brown paint is cracking and both the reddish-brown and dark brown pigments can be dislodged by gentle rubbing with a cotton swab dampened in de-ionised water. The colours appear unchanged. The uneven colouring is due to the manufacturing technique. On the dark brown paint there are the remains of whitish insect casings.

The bark cloth layers are delaminating due to the damp conditions to which the cloth has been subjected. The border is deformed in places. This so-called mechanosorptive creep[7] is caused by changes in moisture content of the material while subjected to applied forces. Extensive water stains are more visible on the reverse side and the fugitive reddish-brown pigments have stained the surrounding areas in places. Soiling at the other end would indicate that the bark cloth has been used as a hanging at some stage; otherwise it appears rather clean.

Chemical tests[8] showed that the bark cloth suffers from extensive cellulose degradation. This has caused yellowing and friability of fibres, and led to a loss of tensile strength. Degradation was further confirmed by pH readings which showed pH 5.4.[9] Correspondingly the pH of new contemporary bark cloth ranges for 6.4 to 6.9.[10]

Treatment
Treatment Proposals
It was regarded sufficient to only surface clean and humidify the bark cloth in order to remove the creases prior to supporting, stabilisation of the bark cloth being the

major concern. The use of conservation erasers[11] was tested but was abandoned because they might enhance dislocation of the pigments and remove brittle fibre particles. Crumbs of the erasure would also be trapped in the coarse bark cloth structure.

The option of stabilising the bark cloth either through wet-cleaning or de-acidification to reduce acidity was rejected. Water would probably raise the pH by 1 - 1.5 pH units,[12] and consequently reach the pH of contemporary bark cloth. It might also help to regain some of the flexibility of fibres. On the other hand there is a risk of further delamination of the bark cloth layers and joints due to a possibility of dissolving the starch adhesive. Water could dissolve natural starches and degradation products resulting in an increase of crystallinity and decrease of wet and dry mechanical strength. Water would also cause swelling and splitting of fibres, and shifting of fugitive colours.

Cleaning
The bark cloth was surface cleaned with a soft brush to remove dust and loose surface soiling. The insect casings were removed from the dark brown paint with a cotton swab dampened in de-ionised water.

Humidification
Chemical stabilisation being out of the question, the bark cloth was structurally stabilised through humidification. The aim of humidification was to relax the creasing in order to maximize contact points with support materials, and also enable rolling without causing further damage. It was chosen to humidify the bark cloth in a purpose-built humidity chamber. Two ultrasonic humidifiers and two fans were installed to provide an even moisture distribution, and to reduce time of air saturation. A hair-hygrometer was used to monitor the RH, and a thermometer to monitor the temperatrure. The RH was gradually raised from ambient to 85%, and maintained stable during the treatment. The bark cloth was manipulated on the creases, and then weighted down where necessary. It took three days to relax the creasing. The distorted borders were further poulticed using layers of dry linen, sandwiching a layer of damp cotton fabric, and covered with polythene to retain the moisture.

After the treatment the bark cloth appeared more even but not flat and it has maintained its natural creasing. The fibres were able to regain only some moisture due to decreased moisture regain, characteristic of degraded cellulose.

Material testing for supporting
As it would not be appropriate to support the bark cloth with methods of conventional textile conservation (fabric would not give enough support to the degraded structure, and stitching would only cause further splitting of fibres) methods of paper conservation were consulted. A number of papers concerning adhesives, bark cloth manufacture and bark cloth conservation were studied. Suitable adhesives and supporting material were found after a series of tests.

Japanese paper Kozu Shi[13] and new contemporary bark cloth were tested using different starch pastes. Experiments were carried out by applying paper and new bark cloth both on damp and dry old bark cloth supplied from the Reference Collection of the Textile Conservation Centre. Better tack was achieved on a damp surface with both materials. Japanese paper was found to be more suitable for smaller patches. It is too regular and flat in contrast with the rougher and more irregular textile of a bark cloth. When used in larger areas papers can produce cockling if applied to a dry surface.[14] Contemporary bark cloth is ideal as a full support, also providing enough support for small tears and natural holes which would otherwise be left unsupported. This method also excludes a need for a separate mounting board. Contemporary bark cloth is more flexible than paper and can follow better the irregularities of an old bark cloth.

A full support provides an additional reinforcement for the bark cloth, enabling it to withstand the stress of being hung. Only applying patches would not strengthen the bark cloth enough for hanging. A disadvantage of the full support includes a certain loss of flexibility. It will also hide the original repair patches but the problem can be minimised by careful documentation.

A starch paste was chosen for application of the patches and the mounting support in order to have similar physical properties to the object's cellulose fibres, eg. hygroscopic properties in order to respond similarly to ambient RH. The adhesives tested were to meet the following criteria: they should be stable and easily removable; have good working properties; in particular they should dry fast in consideration of the fugitive pigments. They should also have good tacking properties but not impair too much the flexibility of the bark cloth after the treatment. Therefore the following properties were considered: rate of drying, stability, reversibility, flexibility and adhesion. The following starches were tested: wheat starch, arrowroot and tapioca (see Appendix 1 and 2). They were chosen for testing because wheat starch is commonly used in textile conservation; arrowroot is traditionally used in bark cloth manufacture;[15] and tapioca is rarely used in conservation.

Tapioca starch was chosen for the treatment as being the most suitable because:

- it is gluten-free, and therefore not susceptible to biological attack;
- according to the tests, tapioca is more flexible than wheat starch and arrowroot, which is important considering the possible rolling of the bark cloth during transportation and storage;
- it has better adhesion properties than wheat starch;
- it is soluble in water and alcohol;
- it leaves a matt surface if applied thinly which is important considering the number and size of patches and the need for something compatible with the object's surface texture.

Further tests were carried out to find a suitable adhesive for adhering the delaminated areas. Two different cellulose ethers in various concentrations were chosen: Klucel G (hydroxypropyl cellulose) and CMC (sodium carboxymethyl cellulose) (see Appendix 2). The use of cellulose ether enables one to distinguish between the original starch paste and the adhesive used in relamination work. Structurally it varies only slightly from the original, but remains noticeable enough to enable future identification of conservation work. The adhesive was pasted onto a slightly moistened bark cloth in order to reduce stress in the structure.

Klucel G, 5% in IMS (Industrial Methylated Spirits), was chosen for the relamination because:

- it can be mixed with organic solvents to speed up the drying of the adhesive in order to prevent possible bleeding of fugitive or powdery pigments;
- it is biologically stable when mixed with solvents which is important when an object is going to be displayed in an uncontrolled domestic environment;
- it does not form irreversible, insoluble complexes with metal ions being non-ionic (in contrast to CMC);[16]
- it is soluble in organic solvents and water which is good for reversibility;
- it is more flexible than CMC containing less cellulose components,[17] which is important if the object is going to be rolled;
- it provides a sufficient adhesion between the bark cloth layers.

Adhering the delamination
The delaminated areas of the bark cloth were relaminated in order to strengthen the structure by increasing the adhesion points between the two layers. The bark cloth was laid face up onto a soft table-top covered with silicone release paper. The delaminated, slightly moistened areas were adhered by lifting one layer with a spatula and applying Klucel G, 5% in IMS, to both layers. The area was weighted with sandbags between blotting paper to enhance drying.

Not all the delamination was adhered; only the areas which would support the structure when mounted vertically.

Supporting tears and holes
Japanese paper was tinted with Liquitex, acrylic polymer pigments (see Appendix 3) to match the area to be patched. The colours were easy to use and the colour proved to be fast in de-ionised water. Wet-tear property was only slightly impaired due to the colouring.

The bark cloth was placed face down onto a table-top covered with silicone release paper. The tinted Japanese paper patches were water-torn according to the templates, the edge of the patch extending approximately 7mm into a stronger area of the cloth. The patches were pasted with tapioca starch, diluted to a consistency of cream, on a blotting paper in order to absorb the excess moisture, and air-floated into the position and tamped down. The area was covered with polyester crepeline to prevent sticking and weighted with sandbags with blotting paper in between. The adhesion was dry within 2 hours. The natural holes and some other holes which do not pose a particular threat to the stability of the structure were left unsupported.

Supporting the borders
The borders of the bark cloth were supported separately with tinted Japanese paper with the method described earlier, in order to give them some extra support and to enable mounting onto the contemporary new bark cloth. The supported borders were finished off by water-tearing the paper along the irregular shape of the border. The feathered edges will form a good adhesion with the backing.

Mounting onto the contemporary bark cloth
The backing which also acts as a mounting support consists of three lengths of new bark cloth. As the width of the new bark cloth measures approximately 66cm, three widths were needed. The lengths were cut to extend the object about 40cm at each end.

The new bark cloth was flow-rinsed

thoroughly with soft water prior to use in order to remove impurities from it. The lengths were laid on Techno-tiles on the floor to allow water through the material. Extreme care was taken during and after the rinsing because wet bark cloth has a very low wet strength. The bark cloth was hand-dried to speed up the drying. When still damp the lengths were laid in layers and covered with polythene sheeting to prevent excess drying before the application onto the object.

In order to have approximately similar moisture content with the backing, the bark cloth was humidified to prevent distortion both in the backing and the bark cloth after the application when dried.

A table-top was covered with Techno-tiles, soft cloth and blotting paper in order to absorb excess moisture after application of the backing. Silicone release paper was placed on the edges to prevent sticking during and after application. The bark cloth was placed face down onto the table and covered with damp cotton muslin and polythene sheeting until slightly damp. The bark cloth lengths were pasted with tapioca starch and transferred onto the object with the help of several assistants. The application was started from the middle and the lengths were tamped down using a wide decorator's brush. The bark cloth was then covered with blotting paper and weighted. The joints do not overlap because this would make rolling the object more difficult and cause stress to the joints. On the front, visible joints were disguised and reinforced by adhering a single layer of new bark cloth over the joints. Both ends were finished off by turning approximately 20cm onto the back for a pole sleeve and adhering it, leaving an allowance for a thin metallic pole. The joint was covered with a thin strip of new bark cloth. The whole mounting process, including preparation, took 12 hours.

Conclusion
The treatment of supporting the bark cloth onto contemporary bark cloth with tapioca starch proved ideal for the purpose. It follows the surface irregularities of the object without causing cockling or looking too flat.

The tinted Japanese paper patches blend well with the surface texture of the bark cloth. The supported areas have maintained the natural creasing, and the patches do not seem to create tension between the different materials. The flexibility of the bark cloth was not greatly impaired by the patching, but the borders lost their flexibility. This might have been prevented by using a lighter weight paper. The mounting onto the contemporary bark cloth further decreased the flexibility but what was lost in flexibility was gained in structural stability, and therefore enables the bark cloth to withstand the stress of vertical display.

Safety
As most of the reagents used in the cellulose degradation tests are both toxic and corrosive, the test should be carried out in a fume hood. Protective clothing, eye protection, gloves and mask should be worn. IMS is harmful by inhalation. Relevant COSHH procedures must be followed.

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Materials and Suppliers

Tapioca (flour)
Foodwatch International
Butts Pond Industrial Estate
Sturminster Newton
Dorset DT10 1AZ, UK

Liquitex
London Graphics Centre
107-115 Long Acre
London WC2, UK

Groomstick
Preservation Equipment Ltd
Church Road
Shelfanger
Diss
Norfolk IP22 2DG, UK

Wishab sponges
Akachemie
Albert Kauderer GmbH & Co KG
D-7315 Weilheim-Teck
Germany

Japanese paper
Falkiner Fine Papers Ltd
76 Southampton Row
London WC1B 4AR, UK

Contemporary bark cloth
Fiji Government Handicrafts Centre
P O Box 2118
Government Buildings
Suva
Fiji

Appendix 1

Preparation of starch paste

4 ½-parts water
1 part starch

Mix 1 part water and 1 part starch and warm slowly, but do not allow to boil. Boil 3 ½-parts water. As the starch-water mixture starts to congeal, stir in 3 ½-parts boiling water. Continue to stir, cooking over low heat until thick and translucent and until desired tack is required.

The mixture can be diluted into desired consistency after preparation.[18]

Appendix 2 : see over

Appendix 3

Tinting paper for bark cloth repair

Acrylic pigments (Liquitex), Japanese paper, 5cm flat Japanese brush, silicone release paper, de-ionised water, bristle brush.

1 Mix colour in a beaker with a stiff bristle brush and a small amount of water (make more than needed). The tone will dry considerably lighter.
2 Dampen the paper first by misting so that brush marks are not formed when colour is applied.
3 Brush colour on lightly with a soft Japanese brush in one direction. It may be necessary to reapply the tinting solution 2-3 times, letting the paper dry between each application, in order to achieve a deep colour.
4 Allow paper to dry on silicone release paper until dry.

All edges should be water torn before use. The more pigment used the more the character of the paper will change. This will not affect its repair potential.[19]

Appendix 2

Results of adhesive testing

Table 1: The adhesives used in testing

	Adhesive	*Adhesion*	*Flexibility*	*Reversibility*	*Workability*
Relamination:	CMC 10%	good	stiff	water	difficult
	CMC 7.5%	good	stiff	water	difficult
	CMC 5%	good	stiff	water	moderate
	CMC 2.5%	moderate	stiff	water	easy
	Klucel G 5% in IMS	moderate	quite flexible	water and organic solvent	easy
	Klucel G 3% in H_2O	poor	quite flexible	water and organic solvent	easy
Patches and backing:	wheat starch	good	stiff	water	easy
	tapioca	good	quite flexible	water	easy
	arrowroot	good	stiffer than tapioca	water	moderate

THE PREPARATION AND USE OF TWO STARCH PASTES

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Introduction

Starch pastes have been used as adhesives for paper for many centuries, and have perhaps been employed for as long as paper has been made. The particular qualities of wheat starch adhesives are well-known and widely utilised in the East as well as in Western cultures. The nature of wheat and other starches is described more fully in the publication by Vincent Daniels.

There are a variety of methods of preparation of starch pastes. Nearly all of these rely on the cooking and manipulation of the starch in water to produce an adhesive. Starch contains two types of molecular units, amylopectin and amylose. Starch granules from different plant sources, and indeed different parts of the plant, vary in structure and in the proportions of amylose to amylopectin units.[1] The larger, branched amylopectins begin to swell and disrupt in water at 55°C. Higher temperatures of over 100°C are needed to fully dissolve the smaller amylose units.[2]

Methods of cooking include conventional preparation in a double-boiler, the traditional beating of Japanese paste, the use of an electric sauce-maker, the Masschelein-Kleiner refinement involving pre-treatment with hydrochloric acid,[3] and the microwave oven. An unpublished recipe for the use of the latter in the preparation of wheat starch paste was given at a meeting of the Institute of Paper Conservation in October 1988 by Anne Leane of the National Maritime Museum. Microwaved pastes are quick and simple to prepare. They have filled a niche in the Organic Materials Section of the Department of Conservation of the British Museum, particularly with local repairs of basketware.

Discussion

Different methods of preparation can give different results. Horie[2] states that vigorous stirring reduces the molecular weight and probably the amount of crystalline material left intact; this has consequences for the nature of the paste. In essence, the greater the beating, the lower the molecular weight and the association between molecules. Controlled hydrolysis of the starch molecules[3] is designed to reduce the molecular weight and thus improve adhesion and flexibility, enhancing its suitability for the backing of large pieces.

Starch pastes made in the microwave oven have two great advantages: economy of time and immediacy of preparation. This is set against the possibility of less than complete cooking. Microwaves tend to heat unevenly, so although mixing can be frequent, some starch grains may remain uncooked. Also, there is little time to observe the subtle changes that occur during cooking, perhaps risking the production of an under- or over-cooked paste. With this in view, most repairs carried out using microwaved pastes are small. Empirical monitoring of repairs carried out over the last five years has revealed no problems, but it remains a point of caution.

Method of Preparation

Ingredients:

Wheat starch paste
10g gluten-free wheat starch
90ml distilled water

Arrowroot-alginate paste
9g arrowroot starch
1g sodium alginate
90g distilled water

Method:

1 Weigh and measure the ingredients carefully and place in a 250ml heat-resistant glass beaker. With the preparation of arrowroot-alginate it is best to mix the two powders intimately, before water is added.
2 Blend the dry ingredients with a little water and stir to an even paste.
3 Add the remainder of the liquid and stir in well.
4 Place in the centre of the microwave and stir for 6 seconds.
5 Remove and stir thoroughly for several minutes.
6 Replace in oven. Continue to cook and beat every 6 seconds until the mixture is fully cooked (about 36 seconds of total microwave time, though this may vary slightly). It then acquires a consistent translucent quality.
7 Allow to cool. Some cooking will continue as it cools.
8 Sieve before use, passing paste through a fine mesh.

Testing

Two starch pastes are commonly used in the Department of Conservation: wheat starch, and arrowroot mixed with sodium alginate. Wheat starch paste has been used in the Western Pictorial Art and Eastern Pictorial Art Sections of the Department of Conservation for some time. It was evaluated along with a range of other starch pastes and cellulose ethers for use in paper conservation by the Research Section of the Department of Conservation in 1990.[4] For paper conservation purposes, wheat starch was found to be the most suitable material of those tested for both sizing and adhesive properties.

The recipe given for the arrowroot-alginate paste comes from a manufacturer of sodium alginate, via paper and archive conservation. Of the two pastes, the arrowroot and alginate has particular qualities which make it especially useful on three-dimensional organic materials. Unlike wheat starch paste, it has a strong immediate tack and so will adhere well on initial contact. This viscosity can be important when a join must maintain a complex position whilst drying. It is flexible when dry, and after artificial ageing;[5] extremely important factors with pliant organic materials.

The arrowroot-alginate paste was tested by the Conservation Research Section prior to use in accordance with the usual practise in the Department of Conservation when considering a conservation material or application new to the British Museum.

A direct comparison with wheat starch paste was considered valid. Both starch pastes were thus made up according to recipe, cooked in the microwave and tested. The reversibility in water, flexibility and appearance of both starch pastes were evaluated before and after light ageing and heat ageing for 28 days. This is approximately equivalent to 50 years of natural ageing.

Results
The alginate-containing starch paste was found to have greater colour stability, retention of flexibility and reversibility than the gluten-free wheat starch paste.

Treatments
The use of the two microwave-prepared starch pastes is illustrated by the two case studies:

Application of a wheat starch paste repair: conservation of the roof of an eighteenth century Japanese portable shrine
The British Museum acquired the gilt and lacquered portable wooden shrine (Department of Japanese Antiquities Registration Number 93 11-1 121) a little over 100 years ago. It imitates the architecture of a wooden temple, with an elaborate housing and silk textile and wood roof above a structure which contains a sacred image. It would have originally been carried through the streets as part of a religious festival procession. The long carrying poles were evidently cut down later, perhaps when it acquired its wheeled cart.

The shrine had many conservation problems: surface dust and dirt, flaking

Table 1: Appearance of starch paste films before and after ageing

	Wheat starch paste	*Arrowroot-alginate paste*
Unaged	Colourless	Colourless
Heat-aged	Film yellowed after 28 days	Colourless
Light-aged	Film yellowed after 21 days	Colourless

Table 2: Flexibility of starch paste films before and after ageing

	Wheat starch paste	*Arrowroot-alginate paste*
Unaged	Slightly brittle	Flexible
Heat-aged	Very brittle, film had crumbled	Flexible
Light-aged	Brittle	Flexible

Table 3: Solubility in water of starch paste films before and after ageing

	Wheat starch paste			*Arrowroot-alginate paste*		
	Sample 1	Sample 2	Mean	Sample 1	Sample 2	Mean
Unaged	99.46	94.70	97.08	29.1	29.94	29.52
Heat-aged	3.11	2.91	3.01	17.00	16.56	16.78
Light-aged	5.79	5.52	5.66	18.91	19.43	19.16

lacquer, detached and broken elements, crude nineteenth century restoration which included misplaced pieces, excess animal glue etc. The condition of the roof textile was of immediate concern. It is of faded green leno woven silk, and was extraordinarily fragile and brittle. It is adhered beneath the wooden lattice of the roof. Several tests were undertaken by the Research Section[6] to identify the dye and determine the presence of sizing on the textile. Analysis showed that no natural dye was present; the green colour is from an azo dye first introduced in 1892. There was no detectable gum, protein or starch on the surface of the textile.

The pH was tested using Merck indicator strips, by contact with a dampened surface, and found to be 4.2 - 4.5. There were many small areas of loss and frequent breaks. The remainder of the textile was thus loose and unsupported, liable to move and tear. Some support was needed for the textile. Silk crepeline was a suitable material, complementing the original fabric and matching the fibre. However, a stitched backing would have resulted in unacceptable damage to the roof textile. Even an adhesive backing would have introduced too much stress, so an additional strengthening mechanism was sought. After tests, it was found that a light consolidation using 3% Paraloid B72 (methyl methacrylate copolymer) in xylene would reinforce the textile sufficiently to allow further work. Also, the presence of the consolidant changed the silk's reaction to water. Instead of a rapid shattering of the fibres, observed under the microscope during preliminary tests, these remained intact and were temporarily more pliant while humidified. This latter quality would allow a water-based adhesive to be used to attach the support; this was desirable because the support could be reversed by humidity without dissolving the consolidant.

Simple tests were carried out to establish the most effective adhesive for attaching the silk crepeline backing to the roof textile and its wooden lattice. In addition to good adhesion, other qualities required were flexibility and relative invisibility. In the tests, detached samples of roof textile were adhered to silk crepeline stretched over a frame. (see Table 4)

Wheat starch paste was thus chosen because it had a matt surface and adhered the silk crepeline flexibly to the silk textile and the wooden roof joists.

To facilitate treatment, the roof had to be removed from its substructure. Many joins had been made with crude nails and/or thick deposits of a protein-based glue. The latter was softened by repeated applications of a water-based poultice containing 7% Laponite RD (sodium magnesium lithium silicate). The glue could then be removed manually using a spatula and residues cleaned off with moistened swabs of cotton wool. Other wooden components were separated by tapping thin wooden wedges between the elements; loosened nails were then removed with pliers. The roof could now be lifted off and inverted in readiness for treatment of the textile.

To prepare the backing fabric, the silk crepeline was washed to remove any sizing. It was then dyed to a matching colour in the conventional manner using Ciba Geigy Lanacron protein dyes. Strips were then carefully cut to widths of 60cm, 47cm and 30cm, matching the distances between the wooden lattice of the roof structure. Working square by square, the strips were adhered to the underside of the roof using the wheat starch paste applied with a sable brush.

When the paste had dried, the roof could be set upright in position once more. Although supported from beneath, there

Table 4: Adhesion and appearance of tested adhesives

Adhesive	*Adhesion*	*Appearance*
1% Klucel G in IMS	Good adhesion, though layers tend to separate when bent	Dried residues show a very apparent sparkle
2% Blanose 7MC in distilled water	Layers separate easily when bent	Very obvious residues remain between weave
Arrowroot and alginate paste	Layers separate when bent	Obvious shiny residues
Wheat starch paste	Layers remained joined, suitable adhesion	Matt residues

remained lifting areas of textile which had still to be stuck down from the upper side of the roof. Areas of the roof textile were gently humidified with moisture from an ultrasonic humidifier to help relax lifting and distorted areas. Again the paste was used, brushing the edges of the lifting areas which were then gently pressed down to adhere them to the crepeline backing. The starch paste had inevitably clogged some of the voids between the weave of the silk textile. Under adverse lighting conditions, and close examination, these were visible.

Conservation of a Northwest coast hat

The chief's hat (Department of Ethnography Registration Number NWC6) depicts a hunting expedition, with hunters in canoes harpooning whales. It had been collected by Captain Cook from the native people in Nootka Sound, British Columbia, Canada. It is of twined construction and made of cedar bark, spruce or cedar root, and grass. The British Museum acquired the hat in 1780, a gift from Sir Joseph Banks.

Poor storage had resulted in breaks around the 'top-knot', apparently due to considerable or prolonged pressure from above. Other breaks and distortions revealed that it had once been folded and stored flat.

After cleaning, a temporary support was made that held the hat in an inverted position. It was then humidified in a temporary chamber at a relative humidity of 80% over a period of several days. This allowed the hat to reassume its original shape and ease out its distortions aided by gravity. Temporary twists of Japanese kozo (mulberry fibre) paper, adhered in place with arrowroot-alginate paste, held the edges of the breaks in register during the humidification process. The twists were removed after the reshaping process by careful wetting with a fine sable brush, avoiding the basketry surface.

Permanent coloured twists of Japanese paper were made, dyed with Ciba Geigy Solophenyl dyes in a manner similar to that of cellulosic textiles. After saturating with approximately 50% arrowroot-alginate paste in water, the excess was blotted off. Several were placed in position, about a centimetre apart, to hold the edges of the breaks close together. Each was pressed into interstices in the basketry fabric using fine tweezers. After allowing to dry over a period of several hours, the results were very satisfactory; the join was strong yet flexible. It is also virtually invisible until closely inspected. A collar of thin Plastazote (polyethylene foam) further supports the top of the hat whilst in storage.

Conclusion

Repairs to organic materials often have very specific needs. The repair material and the adhesive must often be as flexible, if not more so, than the object. Generally a higher degree of flexibility is required; when an extra layer is added, this laminate will stiffen the area considerably. The junction between the pliant and the supported area is thus a potential line of breakage. The exception to this rule occurs when the original material is so weak that it cannot adequately support itself.

Compatible materials such as paper and starch paste can solve a wide range of basketry problems. Raffia 'velvets' from the African Congo have been repaired by backing with a suitably-coloured paper and starch paste patches. Flat, coloured paper elements have been woven in to give additional strength to mats. Twists of Japanese paper tissue (the 'Frankensteins' originated by Nancy Odegaard and Ron Hervey while working in Arizona in 1981) are wonderfully appropriate paper threads which can stabilise three-dimensional basketry structures. Paper and paste may also be used, with all the usual caution needed when treating water-sensitive material, with leather, skin and gut.

Starch pastes are best used within two days of manufacture to avoid problems of retrogradation and mould growth (with the exception, of course, of ten year old paste, where such breakdown is encouraged). Thus a simple and quick method of production, such as with the microwave oven, is ideal. The quantities of ingredients may be halved to produce even smaller amounts of the finished product, so little is wasted. Such convenience of use is very valuable if a material is to be part of everyday workshop practice.

Health and Safety

All materials and techniques should be carried out in accordance with COSHH procedures. The arrowroot, wheat starch and sodium alginate are closely related to foodstuffs, so very safe to use.

Acknowledgements

Kerry Head undertook most of the conservation work on the roof of the Japanese shrine, and Yvonne Shashoua tested the starch paste in the Research Section. The author is grateful to them, and Dr Vincent Daniels and David Thickett, who analysed the roof textile. Thanks are also due to Allyson Rae and Helen Morgan for their advice on the text of the paper, and to Dr Andrew Oddy, Keeper of the

Department of Conservation, for encouragement to publish.

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Materials and Suppliers

Wheat starch
Sodium alginate
BDH Limited
P O Box 11
Freshwater Road
Dagenham
Essex RM8 IQF, UK

Arrowroot starch
Any pharmacist

THE CONSERVATION OF A 19TH CENTURY JAPANESE AINU BARKCLOTH KIMONO AND THE PAPYRUS WRAPPINGS FROM A 3RD CENTURY EGYPTIAN BOTTLE

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Introduction

Different starch pastes are used and have many applications within the diverse material disciplines in the field of organics conservation.

This paper describes two case histories where wheat starch paste was used to solve the conservation problems posed by two different plant fibres in very different types of object. In both objects an adhesive method was essential to solve the conservation problems encountered and in both instances the methods chosen were simple and straightforward to carry out.

The Conservation of a 19th Century Japanese Barkcloth Kimono

This object was described as an Ainu robe from Hokkaido, northern Japan and dated from the 19th century. It was described as an *attushi* costume as the main fabric was a barkcloth and this is the traditional description for barkcloth fabric. It was simply woven in an evenweave structure and made from long fibres believed to have been extracted from the inner bark of young saplings of Elm or Linden native to northern Japan.[1,2]

The garment was decorated with bands of cotton fabric applied onto the barkcloth in an angular pattern around the neck opening, at the back, and at the hem and sleeves. A curvilinear design known as *moleu* was worked on the cotton bands in white cotton thread. There was also a stand-up collar covered in a wool fabric.

Condition

Overall the condition of the kimono was good but there was some surface soiling giving a grubby appearance to the barkcloth. There were also some small abraded holes and tears in the barkcloth and the ends of the silk tie fastenings were missing. The wool covered collar had substantial damage and areas of loss most likely due to insect activity in the past. There was no evidence of current insect activity. Most of the soiling and damage to the robe was consistent with general wear.

Treatment

Neither aqueous nor hydrocarbon solvent treatment was considered appropriate for cleaning the general surface soiling, so the marks were treated using a dry method employing a chemical sponge to lessen them but with little effect in most instances.

Silk crepeline was dyed to colour match using Ciba Geigy Lanaset dye and used to cover the wool collar to give it protection and prevent further fibre loss. It had been decided not to unpick original stitching holding the collar in place so access was not available to support the collar fabric from inside. Covering was therefore the most practical option.

The silk crepeline was also used to cover the fragile silk tie inside the kimono and to make up an extension to the remaining tie fragment on the outside of the garment so that it could be refastened when on display.

The missing and damaged areas of barkcloth were then considered. It was decided to patch the damaged areas using a Japanese paper, colour matched, and adhered behind the holes using wheat starch. Wheat starch paste was prepared according to the recipe given in Huxtable and Webber[3] and thinned with de-ionised water to a consistency of unwhipped double cream.

An Indian/Nepalese paper (Edgeworthia papynfera) was chosen and coloured to match the barkcloth by painting it out onto Bondina using watercolour. The Bondina was used as a base and as a release paper for ease of handling as the Edgeworthia paper was very fine, difficult to handle and easily torn when wet. When dry the coloured Edgeworthia paper was peeled away from the Bondina and a small square was water cut and used to patch behind a sample area of damage. Unfortunately, the appearance from the obverse side was not aesthetically satisfactory although the bond was good and adequate support was provided.

The idea was rethought and it was decided to try to rebuild the damaged area with thin strips of paper fashioned to approximate the appearance of the original barkcloth fibres and thus make a more visually sympathetic repair.

Small strips of Edgeworthia paper were water cut and twisted to make strands like the barkcloth fibres. The strands were painted with wheat starch and laid behind the chosen area of damage along the fibres. Each strip was pressed into place using a mounted needle and fine pointed tweezers. Gradually, twisted paper fibres were laid over the damaged area until enough were applied to give it support.

This repair was carried out to the reverse side of the barkcloth. When dry it provided an excellent support to the area of damage and looked aesthetically pleasing. On the obverse side the aesthetic appearance was again not so good so it was decided to remove the paper strips and do the repair again, this time working from the obverse side. The result was satisfactory.

Repair was then undertaken to a hole. Twisted paper fibres were laid over the hole in both directions to rebuild the missing area. The strips were carefully positioned making sure that each one was well keyed onto the barkcloth fibres. Drying time was allowed periodically throughout the procedure. No attempt was made to actually reweave with the paper strips, rather they were laid in one direction and then in the other in order to build up the support as necessary.

The resulting repairs were harmonious with the barkcloth, judged visually satisfactory and gave full support to the weak and damaged areas.

The Conservation of the Papyrus Wrappings on a 3rd Century Egyptian Bottle

A small glass bottle wrapped with papyrus reed and dated from the third century was presented for conservation. It had been excavated at Oxyrhynchus and had come into the Victoria and Albert Museum collection in 1897.

Condition

The object was dirty and the papyrus wrappings were dry, fragile, broken and dusting away. Several large pieces of reed had broken away and the remaining wrappings had become loose around the bottle. The innermost wrappings were in slightly better condition but the outer ones were very brittle. It was clear that consolidation of the outer reed wrappings in situ, and consolidation and adhesion of the detached pieces, would be necessary.

Treatment

Surface soiling and loose fragments of reed were lifted off using a fine water colour paint brush and fine tweezers. The visible glass part was cleaned by a glass conservator using de-ionised water and cotton wool swabs, then attention was turned to the papyrus reed.

Due to the dessicated nature of the reed a non-aqueous consolidant and adhesive was initially thought to be preferable. A 5% solution of Klucel G (hydroxypropyl cellulose) in ethanol was prepared and tried on a small area at the base of the bottle. The result was not satisfactory as the Klucel did not have the desired qualities of adhesion in this dilute form. It was considered to make a stronger solution but concern was felt that it would be too viscous and there would be a risk of a shiny surface residue remaining after treatment. The test area had darkened slightly but it was such a small change it was thought acceptable if satisfactory consolidation could be achieved.

A second test was carried out but this time wheat starch paste was chosen because it was known from experience to have good qualities of adhesion and will not give up much water into the substrate onto which it is applied if it is properly made and well cooked. A small area at the base of the bottle was painted with wheat starch paste, mixed to the consistency of a thin slurry, in order to consolidate it. It proved successful and when dry held the fibres of the fragmented reed together. There was a slight darkening but it was considered acceptable as the consolidation was so good.

The loose wrappings were carefully manipulated around the bottle until they were no longer loose and about 2 centimetres at the ends of the outer ones were painted with wheat starch and held in place to prevent unwinding. The finest entomological pins were used to hold the reeds down until they were dry.

Loose and broken pieces were then consolidated with the paste and allowed to dry before the broken away fragments were repositioned around the bottle. One by one the detached pieces were examined and their exact positions and order for replacement was noted so that the bottle could be rewrapped as closely as possible to the original configuration. Once this strategy had been worked out each fragment was replaced in order until all the broken away pieces had been accounted for.

When consolidated and repaired it was possible to handle the object once again but it was still fragile. It was therefore recommended that it only be handled by the glass top to place it onto a support and that touching the papyrus reed be avoided.

Acknowledgements

The author would like to acknowledge and thank Lorna Barnes for cleaning the glass part of the papyrus wrapped bottle.

References

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2 To make this traditional cloth the fibres were initially prepared by soaking for a period of about 10 days then split into thin strands and dried. The fabric was usually woven by women using a simple body-tension loom.

3 Huxtable, M and Webber, P, Some adaptations of oriental techniques and materials used in the Prints and Drawings Collection of the Victoria and Albert Museum, Papers from the 10th Anniversary Conference, New Directions in Paper Conservation, Oxford, 14-18 April 1986, Part II, ***The Paper Conservator 2*** (1987), pp 46-57.

Materials

Chemical sponge
Prochem
Professional Chemical and Equipment Company Limited
122 Acre Road
Kingston upon Thames
Surrey, UK

Lanaset dye
Ceiba Geigy Dyes
Hulley Road
Macclesfield
Cheshire SK10 2NT, UK

Bondina non-woven polyester fabric
Atlantis European Limited
146 Brick Lane
London E1 6RU, UK

Wheat starch paste
Conservation Resources (UK) Ltd
Unit 1
Pony Road
Horspath Industrial Estate
Cowley
Oxfordshire OX4 2RD, UK

Klucel G
Conservation Resources (UK) Ltd

THE CONSERVATION TREATMENT OF A JAPANESE FOLDING SCREEN

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Introduction

This paper describes aspects of a conservation treatment carried out on one leaf of an early twentieth century Japanese four-leaf folding screen.

The case history is used to illustrate the preparation and application of a wheat starch adhesive for the support of historic textiles. A range of different support materials including *kozo* paper and silk *habutai* fabric were used. The adhesive was applied at several stages of the treatment: to give a full support to two different textiles; to sandwich newspaper interlinings between tissue-paper; to cover a wood lattice with paper in order to mount the textiles within the screen, and finally to adhere the textiles to this mount. The choice of wheat starch adhesive and the method of application for the conservation treatment were largely determined by the origins of this screen. Screen-making in Japan is part of a highly regarded art form, known as *hyogu*: the mounting of works of art on screens and scrolls. There exist specific traditional materials and techniques for both the manufacture and repair of screens.[1] By adapting traditional Japanese practices and standard European paper conservation techniques, a method of working with the starch paste was devised which suited the textiles, the expertise of a textile conservator and the facilities usually available in the textile conservation workroom. Previous work with starch adhesives carried out at the Textile Conservation Centre by Maria Hayward and Carla Petschek is acknowledged in the development of these techniques.[2]

This was the first time that the author had worked with starch adhesives. The aim of this paper is primarily to share this experience in order to encourage other textile conservators to experiment with starch adhesives, rather than to provide definitive guidelines for use. The screen belongs to a private client, and treatment was requested to make it suitable for use as a functioning piece of furniture in the domestic environment. The work was carried out during 1994 at the Textile Conservation Centre, Hampton Court Palace and was undertaken as a final year student project.

Description and Construction of the Screen Before Treatment

The object was a four-leaf folding screen mounted with textile panels. Each leaf of the screen comprised a rectangular double-sided decorative panel mounted within a carved, black lacquered wood frame. This panel consisted of an embroidered textile on the front and a damask-woven textile on the back, both supported by an internal structure made from a newspaper-covered lattice.

The front textile had a black satin weave ground fabric (silk warp and cotton weft) embroidered with floss silk threads worked in satin stitch (shades of pink, green and brown, all faded to beige). The embroidered motif depicted pendant wisteria branches. The back textile was a damask-woven cotton fabric, with a small-patterned repeat of flower heads on vertical stripes. It had faded from a blue warp and yellow weft to beige. This fabric was lined with tissue-paper, using starch adhesive,[3] which imparted a stiffened and paper-like character. The wood lattice was constructed of four vertical and seven horizontal struts, alternately overlapped and secured with wooden pegs at the outside. Each side of the lattice was covered with two layers of newspaper. The newspapers were printed with Japanese characters in black ink, and were dated from February to April 1907 with the city name 'Yokohama'. They were adhered to the lattice with starch adhesive, and originally formed a smooth support for the textiles. The textiles were adhered to this core with starch adhesive. The adhesive had been applied at the edges only, not over the entire surface.

The overall dimensions of the whole screen standing partially unfolded were: (height) 1930mm x (width) 2400mm x (depth) 450mm; a single panel measured 1281mm x 515mm x 14mm.

Condition Before Treatment

The panel from the front far right hand leaf of the screen was treated. This screen panel was in poor structural condition overall. Much of the damage could be attributed to puncturing.

Both front and back textiles were split and torn. Being mounted vertically, they had slumped and buckled. The satin ground fabric of the front textile was generally sound, but there were several splits where the silk warps had broken leaving cotton wefts fraying in long strands. The embroidery was slightly abraded, and unravelling where the ground fabric had been disturbed. The back textile was more extensively damaged with splits throughout and some loss of material. The cotton fibres were weak and acidic (pH 5); cellulose degradation tests[4] showed extensive breakdown of the polymer, leading to loss of tensile strength, discolouration and acidity. The original tissue-paper backing however remained firmly adhered to the textile and played an important part in reinforcing it, minimising fraying and fibre loss. The newspaper linings were revealed through the areas of damage in the textiles. The newspaper was discoloured, acidic (pH 4) and broken up into fragments; it no longer functioned as a smooth covering to the lattice or support to the textiles. The wood lattice was fractured in several places and misaligned struts had pierced or deformed the textiles.

Conservation Treatment Carried Out
The screen panel was removed from the frame and dismantled into its component layers which were then treated individually.

The original starch adhesive attaching the textiles and newspaper interlinings to the lattice was released by the application of moisture. Strips of damp filter paper were placed over the areas where the adhesive had been applied; these were covered with glass weights and left for 30 minutes. The textiles and newspapers could then be lifted off using a micro-spatula.

The textiles and newspapers were washed in de-ionised water. Further details of this procedure can be found in the full conservation report available at the Textile Conservation Centre.[5] The original tissue-paper lining from the back textile was not removed during wet cleaning; although the starch adhesive softened in the water and the tissue-paper swelled, they did not separate.

Adhesive support of textile panels
Both textile panels were given a full support lining using a wheat starch as the adhesive.

Two different support materials were used. A commercially-dyed light-weight silk *habutai* fabric was used for the front embroidered textile, being visually and texturally sympathetic to the panel. A Japanese mulberry (*kozo*) paper of the *sekishu-shi* type was used as the support material for the back textile. In order to infill the areas of loss in this textile, the support paper was tinted before it was adhered. A template was used to indicate which areas were to be coloured. The method of colouring was chosen for good water fastness properties in light of the subsequent aqueous adhesive treatment. 'Liquitex' acrylic colours were used - pigments applied in a matte acrylic polymer emulsion medium. Colours were blended and applied with a hard-bristled brush which gave satisfactory results emulating the texture of the original textile.

A wheat starch adhesive was prepared by blending one part wheat starch powder and four parts water in a glass beaker. This was cooked directly on an electric hotplate for 30 minutes, whilst being stirred continuously. A gelatinous, glossy white paste was formed. After cooling overnight, the firm gel was sieved through a potter's sieve and beaten in a mixing bowl whilst being diluted with water. The resulting paste was viscous yet liquid enough to drop off a spoon; the consistency of thick unwhipped double cream. Batches of paste were made as required, and were used within two days of preparation. The paste was stored at cool room temperature (approximately 12°C), covered with a damp cloth. No fungicide was added.

The technique of applying the support was adapted from traditional wet lining methods, described in Huxtable and Webber.[6]

1 The textile was placed face down on a Formica table-top covered with Vilene, an absorbent non-woven polyester fabric. An adjacent work table was first covered with Vilene and then with a piece of Melinex cut to the exact size of the support; the support material was placed face up on this. Both object and support were gently wetted with de-ionised water applied with a spray, and left to stand for 5-10 minutes. Initial aligning of loose yarns and fragments on the degraded textile was carried out.
2 The support material was pasted with prepared starch adhesive and left for 5 minutes for surface water to evaporate, leaving the adhesive tacky. The paste was applied with a special Japanese pasting or squeezing brush, a *shigoke*. This has many short soft bristles which enable the brush to carry a good supply of paste, but also can be used to 'squeeze' excess paste off the support material by working it across the surface in outward movements. The Vilene covering on the table absorbed excess paste.
3 The pasted support material was transferred to the reverse of the textile using the Melinex underneath it as a carrier. Because the support adhered well to the Melinex, it could be held upside-down in position over the textile and lowered gently in place. The Melinex was removed.

4 The adhesive bond between the support and textile was consolidated by brushing through the reverse of the support material. A Japanese *nadebake*, or smoothing brush, was used, first held at a low angle to glide across the fabric, and then vertically to tamp the support into the uneven surface of the embroidery. The long hard bristles of this brush are particularly suited to sliding across the wet support.
5 The whole system was picked up using the bottom layer of Vilene as a carrier and reversed directly onto the adjacent table, so the textile was face up and the support material laid directly on the Formica table-top. Adjustments were made and loose threads stuck down with additional adhesive applied with small brushes as required. Since the paste was slow drying and had good 'slip' properties, re-adjustments were easy to make.
6 False margins or *tegami* were applied to ensure that the textile dried flat, drawn out under slight tension. Torn strips of *kozo* paper were pasted with a thicker wheat starch paste and adhered so that they overlapped the excess support material and the table top, around all edges. This is an important stage since without these the textile would tend to buckle and wrinkle on drying.
7 Initial drying was slowed down by covering the surface with muslin cloths for a day; too rapid drying may lead to poor adhesion. It was left to air dry for 5 weeks.

Adhesive support of newspaper interlining

The newspaper interlinings were to be retained within the matrix of the screen because of their provenance value. They were sandwiched between semi-transparent supports which still allowed the print to show through. A Japanese *kozo* tissue-paper, *tengujo*, was used because of its degree of transparency and because its long fibres impart a relatively higher dry strength compared to a European lens tissue. A wheat starch paste was again selected as the adhesive. The application procedure described above was modified owing to the poor wet strength of the *tengujo* paper, the fragmented condition of the newspaper and the sandwiching process. The *tengujo* was difficult to work with (compared to the *sekishu-shi*) because it wrinkled as it swelled on wetting out and tore when manipulated, even during pasting. The newspaper therefore had to be transferred to the support material rather than *vice versa*. The work was carried out as follows:

1 Since the adhesive tended to seep through the *tengujo* paper and stick the support too firmly to the table, the table-top was specially prepared. Terylene, an open weave polyester mesh fabric, was pasted to the table with a watered down wheat starch paste, and allowed to dry.
2 The bottom layer of *tengujo* paper was laid on the Terylene surface. Three sheets were used, overlapping by 10mm to achieve the required size. Moisture was introduced very gradually, so that the paper did not cockle, by covering the paper with damp Vilene.
3 The starch paste was brushed onto the paper through a Terylene screen, as in screen printing, to prevent the paper tearing. It was then left to stand for 5 minutes.
4 Newspaper fragments, wetted with a spray, were placed in position face uppermost on the pasted paper. Both layers of newspaper were applied, one on top of the other, without any paste in between them.
5 The covering layer of *tengujo* paper was applied dry. It was unrolled from a roller which made handling easier. Paste was then applied, again brushed through the Terylene screen; although pasting from the 'wrong' side, the adhesive soaked through the *tengujo* and formed the adhesive bond between it and the newspaper.
6 *Tegami* strips were applied as previously described.
7 After drying for 5 weeks, the supported panels were removed firstly from the table-top together with the Terylene. The Terylene was then gently peeled away.

Preparation of the lattice

The wood lattice was repaired using a commercial wood glue, Evostick Resin W. It was then prepared by covering each side with layers of Japanese *sekishu-shu* paper, to replace the original newspaper coverings.

Traditional paper linings of the Japanese *karibari* or drying board were adapted.[7] A *karibari* board is constructed of a light wooden lattice core covered in a specific way with up to seven layers of Japanese paper applied using wheat starch adhesive. As part of the Japanese *hyogu* mounting process, art works on paper or silk from screens or scrolls are attached to the *karibari* and tension-dried and stretched for up to a year following the application of the starch adhesive lining. The smooth yet cushioned, strong and flexible surface of the *karibai* responds to environmental fluctuations in harmony with the object. This long-term stretching ensures that the mounted panel will not distort and will hang or lie flat even after rolling, since the textile retains a 'memory' of lying flat.

This seemed to offer a good method for recovering the lattice and providing a suitable surface for mounting the textiles. In this case only two layers of paper were applied to each side of the lattice, rather than the traditional seven. The paper was cut to appropriate shapes and the pieces were applied wet, with a thick starch paste. Each layer was left to dry for several days before the next one was applied. This stage presented some difficulties. There was a tendency for the conservator to distort the wet paper by trying to make it taut on the lattice, because it appeared saggy and wrinkled when first applied, and this resulted in the paper drying cockled. In fact, because the paper was applied wet, it contracted on drying and became taut without any need for manipulation.

Re-assembly of the panel
The supported textiles and newspaper interlinings were re-applied to the lattice core in two stages. The newspaper panels were applied first, one to each side of the lattice. After two days, the front and back textiles were secured over them. In each case thick starch paste was applied to the outer edges of the lattice only. The textile or newspaper panel to be attached was humidified with damp Vilene, as was the lattice core. It was then positioned on the lattice from a Melinex roller. The edges were pressed down to ensure good contact with the paste. The panels dried under tension (held by the paste at the edges) and were drawn smooth and flat to the lattice. One side of the core was worked on at a time, and allowed to dry under weights to prevent warping of the lattice. Once dry, excess support material was trimmed off from around the edges with a scalpel.

The mounted panel was then re-attached in the frame.

Observations and Evaluations of Treatment
The method of applying the adhesive support was relatively straightforward to carry out. The procedure was quick - for example it took four hours (2 conservators x 2 hours) to prepare and apply the support to one textile. A large work space and two people were required to carry out the treatment, and adequate table space was needed so each panel and its support could be laid out separately. It was important to think the whole procedure through in advance so materials were correctly placed and handling kept to a minimum. The handling of large areas of wet, pasted support material was difficult, and in this case much depended on the inherent strength of both the objects and the support materials. The use of the Melinex carrier made it easier to manoeuvre the support, rather than the more traditional method of 'pitching' the support onto the object from a batten. The support could be aligned in position safely before any contact with the object was made, and could not fold or stick to itself.

Melinex and other equipment and materials commonly found in the textile conservation studio were successfully adapted for use. Formica table-tops on trestles were particularly helpful since they were portable and could be stacked vertically or horizontally in storage during the long drying time, even with the object attached to them. They provided a smooth surface against which the textile could dry directly, without adhering. They functioned in place of the *karibari* or drying board. Because the textiles were to be fixed permanently onto the wooden lattice in the screen, the long-term stretching and the unique characteristics of the *karibari*, which ensure the textile hangs flat, were felt to be less important. The drying/stretching time of five weeks in this case was rather arbitrarily chosen, being the period of the Easter vacation at the TCC; however as long a period of time as possible would be recommended. If the panels were released too soon after the application of the support lining, the strength of the adhesive bond might be affected and the panel would tend to curl at the edges. The Vilene fabric was useful. It absorbed soiling released on wetting out, excess moisture and paste, and prevented rapid drying out whilst tamping and re-alignment took place. Fragments were readily held in position on it, but did not adhere when the Vilene was removed (unlike Melinex). Two specialised Japanese brushes, purchased in Japan, were used: a *shigoke* or squeezing brush, and a *nadebake* or smoothing brush. Conservators are increasingly using Japanese brushes, since they are precisely adapted to specific functions in the lining process. However there is a good range of bookmakers, paint and wallpaper brushes available in this country that can be used instead.

The main problem encountered during the application of the support which could not be overcome was the slight staining of the support materials caused by the release of coloured degradation products from both textiles and newspapers on wetting, even though they had been cleaned beforehand. The adhesive also slightly altered the colour of the toned infills.

The completed treatment, evaluated in terms of overall benefit to the screen, had pleasing results. The physical state and appearance of the panel were improved, facilitating the screen's continued use. In terms of the individual components, both textiles were structurally stabilised and could be mounted safely within the screen. However, they were significantly stiffened as a result of the adhesive treatment.

In general, better results were attained with the damask-woven back textile, in terms of adhesion and visual appearance. Good adhesion was achieved between the tissue-lined cotton textile and paper support, and loose yarns and fragments were secured. The embroidery and the black satin ground made it less easy to accomplish good results with the front textile. Although good initial adhesion was achieved, the support silk detached in places when the panel was re-humidified for application to the core. The bulky embroidery made close contact between adherends difficult. The long weft strands were held in position acceptably, but loose embroidery threads were difficult to secure and could only be adhered by applying extra paste to the front of the textile which affected the appearance. Residual starch, although colourless, was visible on the front of the black satin ground. The textile was very inflexible when dry. In particular the embroidery threads were so impregnated with starch that they were severely embrittled, and tended to crack off if the textile was flexed, resulting in some damage. This loss of flexibility was acceptably only because the textiles were to be permanently mounted flat in the screen. The form of the treatment demanded that work took place quickly and in one stage - before the paste dried (within 30 minutes). This meant that the repositioning of loose threads was not as precise as if they had been relaid and secured individually (as, for example, in a stitched conservation technique). The starch adhesive did not immediately 'fix' positioned threads, and they tended to shift.

In the light of the results on this panel, modifications to the treatment could be suggested for subsequent panels. It is felt that the wetting of the textile and support prior to initial application of the paste resulted in the movement of the paste from the interface of the textile and support into the textile fibres on drying, making them stiff. Although it is generally recommended that the two adhered surfaces are wetted in order to achieve a good adhesive bond when using a starch paste, perhaps the extent of this wetting could be modified. A gentler procedure might be offered by, for example, letting the pasted support material dry before applying to the object, and then re-activating the adhesive *in situ* by gentle humidification. A low-pressure vacuum suction table might improve bonding. Increased experience would undoubtedly improve the wet lining technique. Supplementary stitching might be an additional option to secure loose weft floats and embroidery. However, the starch may preclude stitching; the stitch-holes creating perforations in the stiffened textile.

Conclusion

The poor flexibility of the supported textiles in this particular case might seem to limit the situations where either the adhesive or the application method would be appropriate in textile conservation. However, the highly successful treatment of oriental scrolls in the *hyogu* tradition demonstrates that both the wheat starch adhesive and the wet lining techniques can produce good results in terms of adhesion and flexibility. The main conclusion to be drawn from this case history is that a high degree of skill and experience are required to perfect the techniques. Although the procedure seemed relatively straightforward and quick to carry out, subtle factors such as the extent of wetting, the amount of starch paste applied, the thickness of the paste, the amount of pressure and pounding required to achieve a firm bond determined the success of the treatment. The acquisition of these skills and experience may be difficult for the occasional user, but this factor should not prevent new users from experimenting with starch adhesives and applications. This one treatment has already produced for the author a far greater understanding and feel for the material, and many ways in which the application of the adhesive could be improved have been revealed. Starch is an extremely versatile adhesive; it can be used to fulfil a whole range of functions within a single treatment, with many different materials. For an object such as this screen, a starch adhesive was perhaps the only ethically viable option for treatment in light of the screen's origins and 'true nature'. It has a valuable place in the adhesive repertoire of the textile conservator. Textile conservators are encouraged to experiment for themselves and it is hoped that this forum will generate the enthusiasm to do so.

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I would like to extend special thanks to Andrew Thompson, Department of Conservation, The British Museum, who demonstrated some of the techniques of the traditional *hyogu* studio, and Jacky Padfield, Public Records Office, Kew.

References

1 There are several sources of information regarding the *hyogu* techniques available to the conservator, for example: Koyano, M, ***Japanese Scroll Paintings: A Handbook of Mounting Techniques***, Foundation of the American Institute for Conservation, Washington DC (1979); Huxtable, M and Webber, P, Some adaptations of oriental technqiues and materials used in the Prints and Drawings Conservation Department of the Victoria and Albert Museum, ***The Paper Conservator 9***, Institute of Paper Conservation, London (1987), pp 46-57; and Usami, N, The construction and repair of Japanese folding screens, ***The Conservation of Far Eastern Art***, preprints of the contributions of the IIC Kyoto Congress (1988).

2 Petschek, C, The conservation of pro-royalist painted silk panels from a late 17th century folding screen, ***Paper and Textiles: The Common Ground***, SSCR Edinburgh (1991), pp 117-123.

3 Samples of all adhesives were identified using a chemical spot test to detect the presence of starch with potassium iodide solution.

4 Two chemical spot tests, the Fehlings test and the Turnball blue test, identified the presence of aldehyde and carboxyl groups in cotton fibre samples. This indicates that depolymerisation of the cellulose has occurred.

5 Pullan, M, The conservation treatment of a Japanese folding screen, unpublished student report, The Textile Conservation Centre (1994).

6 Huxtable, M and Webber, P, ***op cit.***

7 Webber, P and Huxtable, M, Karibari - the Japanese drying board, ***The Paper Conservator 9***, Institute of Paper Conservation, London (1985), pp 54-60.

Materials and Suppliers

Japanese papers
Falkiner Fine Papers
76 Southampton Row
London WC1B 4AR, UK

Wheat starch
Merck Ltd (formerly BDH Chemicals)
Hunter Boulevard
Magna Park
Lutterworth
Leicestershire LE17 4XN, UK

Silk habutai
Liberty's plc
Regent Street
London W1R 6AH, UK

Vilene and Terylene
John Lewis plc (all branches)
Oxford Street
London WC1, UK
Vilene is sold as interfacing in the dress fabric department. Terylene is sold as net curtaining in the upholstery fabric department

Japanese brushes
Masumi Corporation
4-5-2 Sugamo
Toshima-ku
Tokyo 170
Japan

Melinex
BSG Group
49-53 Glengall Road
London SE15 6NF, UK

Liquitex acrylic colour
London Graphic Centre
107 Long Acre
London WC2E 9NT, UK
(Binney & Smith Inc manufacturers)

STARCH PASTE TREATMENT OF A FLOORCLOTH BANNER

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The Floorcloth Banners and Floorcloth Production

This early 20th century floorcloth banner is one of a unique collection of five similar banners which belong to Kirkcaldy Museum and Art Gallery in Fife. These banners were made by the firm of Michael Nairn and Co Ltd, one of the two largest floorcloth and linoleum firms in 19th century Scotland, both of which were based in Kirkcaldy. Floorcloths were produced commercially from approximately 1847 and by the early 1900s they had passed the peak of their popularity. Floorcloth is a forerunner of linoleum which took over in the floor covering market, as despite its popularity, floorcloth lacked softness, warmth, durability and the ability to deaden sound.

Floorcloth is made by stretching a heavy jute canvas as tightly as a drum onto large wooden frames; the canvas is then sealed with several coatings of a thin liquid size. A thick coating, consisting of an oxidised linseed oil and pigment mix, was then trowelled onto the sized canvas. Each piece of canvas was 25 yards long and eight yards broad. Every piece received a number of coatings, each of which had to dry before the next could be applied. Both sides were treated, the upper side receiving more coats than the backing. Polishing with pumice stones between each coating ensured a smooth surface and grip for the next coat.

The resulting floorcloth was then block printed, great precision being needed to ensure the pattern was printed accurately. Mistakes had to be scraped off and reprinted.

After printing, the floorcloth was matured or seasoned in the drying chamber. Until the 1860s this was done by opening some of the factory windows and allowing natural air drying to slowly take effect. In the 1860s the drying time was much reduced by the use of blasts of hot air from a steam engine, with moisture added to prevent cracking or excessive drying of the cloth.[1,2] Once dry, the floorcloth was varnished.[3]

Floorcloth Banner 'Lang May His Lum Reek' (KIRMG 1983-77)

The floorcloth banner (SMC T128) is approximately 1.57m in length and 1.70m in width. It is double-sided and appears to have been made using an offcut or sample of floorcloth. Both the top and bottom edge were held rigid by wooden hanging poles. These have been made by splitting round wooden dowels into two halves and fixing the two halves on either side of the banner, securing them with a number of iron screws. Then the wooden poles had been painted. On the front of the banner, on a white ground, a hand painted design shows a red and green factory building housing four Lancashire boilers. These boilers were used in the production of floorcloth, as were the crossed shovels and spades painted either side of the factory building. Two mottos on the banner celebrate the marriage in 1907 of Lieutenant R Spenser Nairn, the factory owner's son. The back of the floorcloth is hand block printed in yellow, green and red with a geometric, floral tile-like design. A shield, emblazoned with three thistles and a scroll bearing the word Nairn's, has been hand painted into the centre of this side.

Condition

The banner had been stored loosely rolled around the original hanging pole and was buckled, very dirty and creased. Examination left one's hands black. There were rips, mainly at the edge, in five or six places, and some small pieces were missing. The banner was torn away from the bottom pole for approximately 200mm. While rolled, the front and back surfaces had become stuck together at points where the surfaces were raised because of the texture of the canvas. Where the pressure had been acute, small dots of the surface paint layer had transferred from one side and had become stuck onto the other. In a few areas along the banner and ripped edges the ground layer as well as the upper paint layer had become completely detached, exposing the jute canvas.

Conservation

A literature review carried out during the treatment of the floorcloth banner revealed no published information on the treatment of floorcloth or linoleum.

In order to carry out the treatment, the two poles were first removed from the banner. First a putty-like filler, which had been painted over, had to be scraped away from the screw holes before the screws could be released. Removing the poles revealed that the area underneath was almost as dirty as the exposed surface, despite the extremely tight fit that might have been expected to exclude dirt. It was speculated that the banner may have been made from a piece of floorcloth that had been lying about the factory for some time.

The conservation treatment started with surface cleaning and mechanical removal of the redeposited small fragments of floorcloth paint surface and ground. Surface cleaning was carried out using enzymatic action provided by saliva, a method pioneered by painting conservators. This method was chosen as being more effective than a water and detergent mix but not as harsh as solvent cleaning. Areas of 100mm to 150mm square were treated at a time. Saliva was applied with a small bristle brush and worked to release grime, which was then swabbed away with a regular change of cotton wool swabs dipped in soft filtered water. Caution needed to be taken around the exposed jute canvas in case the grime was sucked into the fibres rather than rinsed away.

It was found that if care was taken a micro spatula could be used to detach the redeposited accretions of floorcloth from the banner. Where possible this was continued to reveal the design beneath. Removal of the accretions from the back of the banner proved to be less successful than removal from the front. Tests showed that adhesions which had been picked off the back sometimes resulted in the original surface being sacrificed. This was an undesirable effect and therefore it was decided to reduce the adhesions in height by abrading them. A fine grade of glass paper was used.

The response of the floorcloth to slightly plasticise in the presence of moisture had been noted when treating the first floorcloth banner (With Best Wishes T101 KIRMG 1983-76). This response was exploited when treating floorcloth banner T128. In order to relax the distorted, buckled areas they were given a light brush of softened filtered water and once this had penetrated and softened the floorcloth, glass weights were applied and left in position overnight.

Watercolour treatment

Purely from a conservation point of view, it would have been considered acceptable to have left the pattern loss as it was. Aesthetic and curatorial issues however needed to be taken into consideration. The large areas dotted with missing points of pattern were distracting, especially on an object whose essential importance was its design; on one side an original floorcloth pattern, and on the other side a commemorative banner. Watercolour[4] in-painting was therefore decided upon as a suitable and easily reversible means of conveying the impression of the whole. In a raking light the satin sheen to the surface of the undisturbed floorcloth is easily distinguished from the matt or slightly raised surface of the watercoloured areas. The matt appearance signifies where the surface has been removed and the raised surface indicates where adhesions which had been too hazardous to remove had been left in place and painted over.

Wheat starch treatment

Due to the request from the museum that both sides of the banner should be visible after conservation, the most usual technique involving surface cleaning the banner and laying it on a large angled plinth was clearly inappropriate. A method of reinforcing tears and strengthening edges which would impart enough strength to allow the banner to be hung and yet not be too obtrusive to the eye was sought.

The floorcloth banner treated previously (T101) had been treated using as adhesive film Beva 371 (a mixture of ethylene vinyl acetate copolymers, ketone resin N and paraffin) in conjunction with a fabric support, Stabiltex (polyester multi-filament sheer weave fabric). The Beva film had been firmly bonded onto the support fabric with a hand-iron set at around 85°C using silicone release paper as a protective layer between iron and film. Cut strips of the Stabiltex and Beva film support were then applied along tears with a hand-iron set at around 85°C using silicone release paper as a protective barrier. The result looked smooth and almost shiny; it seemed as if the adhesive had melted onto the surface of the floorcloth. This did not appear to be a reversible technique either. When reviewing that effect, therefore, it was decided not to use a technique using a heat setting adhesive for treating T128. Solvent-activated adhesive techniques were also rejected to prevent the solvents interfering with the floorcloth ground or varnish finish.

It was decided, therefore, to carry out tests using adhesives activated by water: wheat starch paste[5] and a 25% solution of Mowilith DMC2 (polyvinyl acetate) in de-ionised water. Four different types of supports were sampled: Reemay (polyester non-woven tissue), 'L' tissue (acid-free, unbuffered, long fibre paper), Stabiltex and silk crepeline. Of the starch paste tests the crepeline gave the poorest bond. Stabiltex looked translucent and provided a good bond. The Reemay and the 'L' tissue both appeared frosted on drying. The Mowilith DMC2 samples all had an extremely firm bond and appeared translucent. The test strips were approximately 80mm by 30mm and were sited along the top edge of the banner; this edge would eventually be covered when the banner was reconstructed. Reversibility tests showed that the support fabrics and tissues could be peeled off from the starch paste sites and then the starch paste removed using saliva and soft filtered water swabs. Reversibility tests on the Mowilith DMC2 samples showed different results; the Stabiltex, crepeline and the Reemay could be peeled off, but the 'L' tissue pulped and had to be brushed off carefully. On the application of a light wash of water the Mowilith DMC2 did gel but such was the concentration of moisture in the floorcloth that it too appeared moist and putty-soft; it was therefore impossible to brush or scrape the adhesive off.

As a result of these tests, wheat starch paste and Stabiltex were chosen as the adhesive and the support material. The Stabiltex patches were laid in place and paste smoothed over them, care being taken not to disturb the watercoloured areas. The pasted areas were weighted down overnight to stop the presence of moisture from causing the distortions to re-assert themselves. The paste needed at least an hour to dry off to prevent the glass weights sticking to the patches. Both sides of the banner were treated with patches and it was decided to infill the area of loss at the edge of the banner in order to stabilise the structure. A scoured linen was chosen as the most aesthetically pleasing and similar to the jute substrate of the floorcloth. This was dyed using Helizarin pigment pastes and cut to fill the area of loss. The edges of the fabric were frayed where it was possible to overlap them with the damaged edges of the jute substrate, in an attempt to provide more strength. Once treated with starch paste, the linen patch appeared somewhat 'frosted' and so was given a light watercolour wash to reduce this effect.

Display and Storage

Incorporating preventive conservation methods into the new display, storage and transport system was an integral part of the conservation planning; the aim was to allow museum staff as much ease of handling as possible while providing the protective support which was necessary to safeguard the condition of the banner. The display requested that both sides of the banner be visible, the desirability of maintaining the integrity of the object by continuing the use of the original poles and the maxim 'keep it simple' worked together to suggest a suitable display mechanism. It was suggested to the client that two thin flat aluminium batons be cut for the top edge but that they should be longer in length than the original poles. These batons would be drilled with screw holes to correspond with the originals and the whole system should be reassembled with the aluminium batons extending beyond the end of the banner where extra drill holes would take hooks. In this fashion both sides of the banner would be available to view, and the original appearance of the banner would be preserved as far as possible.

It was planned that these batons and poles would be removed before the banner was rolled for storage. A rolled, rather than a flat, storage system was preferred by the museum and so a PVC pipe 315mm in diameter[6] was covered with Melinex (polyester film) and the banner was rolled around this interleaved with sheets of silicone release paper. An outer wrapping of Tyvek (polyethylene non-woven fabric) and the provision of two labels prepared the banner for storage.

Comments

The treatment appears to be successful and it is felt to be a more sympathetic technique than that used on the first banner. Though it was not possible to carry out exhaustive laboratory tests on the adhesive treatments used, the treatment described here was, it was felt, the most promising, given the circumstances and the tests that were carried out. It would be interesting to hear of the experience of others working with any project of a similar nature, and most useful to hear suggestions of how different approaches may have been investigated.

Safety

Helizarin textile printing system binder contains white spirit. White spirit can cause severe eye irritation and de-fat skin on contact and is also highly flammable. Appropriate gloves and eye protection should be worn. Handling and application should be carried out in an area with a satisfactory ventilation system.

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References and Notes

1 Grant, G, Mechan, D and Seymour, V, ***The Queer Like Smell: The Kirkcaldy Linoleum Industry***, Kirkcaldy District Council (August 21, 1992).

2 This small catalogue accompanied an exhibition of the same name and is available from: Kirkcaldy Museum and Art Gallery, War Memorial Gardens, Kirkcaldy, Fife, KY1 1YG.

3 Nairn's Public Relations Department, ***The History of Michael Nairn and of Linoleum***, unpublished lecture notes.

4 Schmicke watercolour paints, and numbers 1, 0 and 00 Windsor & Newton sable brushes.

5 Wheat starch paste recipe: 1 dessert spoon starch paste, slightly heaped; 15 spoons of water. Mix until adsorbed. Boil in a double boiler stirring almost continuously, especially at the point of thickening, 10-15 minutes after coming to the boil. Store in water in a fridge. Sieve for use, adding water if necessary. NB: for maximum tack make on the morning of use.

6 Caution: a pipe this diameter is very heavy. It has to be bought as a 6m length but most sellers will be able to cut it before delivery, at extra cost.

Materials and Suppliers

Helizarin textile printing system
Hays Chemical Distribution Ltd
Colour and Special Chemicals Division
55-57 Glengall Road
London SE15 6NQ, UK

Linen scrim
F R Street
Frederick House
Hurricane Way
Wickford Business Park
Wickford
Essex SS11 8YB, UK

Melinex (polyester film, grade O)
PSG Group Ltd
Polymet House
49-53 Glengall Road
London SE15 6NF, UK

Wide diameter pipe
Quay Pipe Supplies
18 Harmsworth Street
Glasgow G11 6LU
Scotland, UK

Silicone release paper (silicone release, vegetable parchment, grade A.18)
Cotek Papers Ltd
Dracott
Moreton-in-Marsh
Gloucestershire GL56 9JU, UK

Stabiltex (polyester multi-filament fabric, Tetex Pes-4)
Plastok Associates Ltd
79 Market Street
Birkenhead
Wirral L41 6AN, UK

Schmicke watercolours
L Cornelissen & Son
105 Great Russell Street
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THE USE OF POTATO STARCH PASTE TO ADHERE SILK WALL COVERINGS IN SANSSOUCI

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Introduction

The aim of this paper is to highlight a German exhibition catalogue: K Paepke and M Massel's ***'Textile Kostbarkeiten in Sanssouci bewahrt'***[1] (English translation: 'Textile treasures preserved in Sanssouci'). The catalogue documents textile wall coverings, tapestries, upholstery top covers and costume in the care of the Stiftung Schlösser und Gärten Potsdam-Sanssouci, which have been the subject of an extensive programme of conservation, restoration, reconstruction and renewal since 1969.

The catalogue includes a case example by Christa Zitzmann, in which she describes the use of potato starch paste to adhere silk wall coverings.[2] Christa Zitzmann is one of the conservator-restorers at Potsdam and Sprecherin der Textilrestauratoren im Berufsband AdR (Chair of the Group of Textile Conservator-Restorers of the German Association of Conservator-Restorers).

It should be noted that the following observations are based only on the published catalogue and a recently drafted English translation of it.[3] It was hoped that Christa Zitzmann would speak at the forum. Unfortunately this was not possible. However, it was decided that the catalogue merited wider attention and that a brief introduction to it would contribute to discussion at the forum.

The catalogue, 'Textile treasures preserved at Sanssouci', records an exhibition held in 1993 at Sanssouci. This palace was built between 1763 and 1769 for Friedrich II of Prussia and a fine collection of eighteenth and nineteenth century furnishing textiles is preserved there and at the New Palace. The exhibition focussed on an extensive preservation and presentation programme undertaken at Sanssouci for the textile wall coverings, tapestries and upholstery top covers. The catalogue is of special interest: it not only records the treatments undertaken (ranging from conservation, restoration, reconstruction to renewal), but it also explains the rationale behind the treatment decisions.

The catalogue is divided into four parts:

1 An introductory essay by Karola Paepke, the curator of the textile collection at Potsdam.
2 A list, arranged in chronological order, of all work carried out on the textiles since 1969.
3 Five case histories, illustrating the conservation problems posed by furnishing textiles on open display.
4 Catalogue entries for the 72 exhibits.

The catalogue is well illustrated: colour photographs show some of the recently restored interiors; black and white prints show room arrangements as they were in circa 1900. For example, the colour illustration on page 20 shows a bedroom in the New Palace with its restored silk wall coverings and a replica carpet. The silk wall coverings (Catalogue No. 35), with a design of chrysanthemums, were woven in Lyon in 1893 by Tassinari and Chatel. Fragments of the eighteenth century original remain (Catalogue No. 34). The carpet (Catalogue No. 8) was copied in 1985 from an eighteenth century original (Catalogue No. 7: a tapestry-woven silk carpet, woven in Berlin in c.1765, by Charles Vignes Erben).

Most exhibits are illustrated and the catalogue entries include details of any conservation or restoration treatment. In addition, the use of replicas is well documented; for example, replica tassels and cords are photographed alongside the originals.

Christa Zitzmann introduces the problems encountered in preserving and presenting the Rococo interiors at Sanssouci and the New Palace. She outlines the restoration possibilities of textile room ensembles and presents two case examples; one of these involves the use of potato starch paste.

Zitzmann explains that textiles became the dominant element in Rococo interior decoration. She notes that silks are vulnerable and disintegrate quickly on open display, resulting in the survival of few original eighteenth century silks. She records that in the recent past damaged cloths were replaced, signifying a loss of both original material and 'historical identity'. She notes the value of conservation techniques but identifies their limits. She states that her goal in working with textile interiors is 'protecting the impression of the room as a complete architectonic artwork. The many metres of fabric widths (in silk wall coverings) cannot be dealt with as single pieces and because of this classical restoration methods with needle and thread are seldom made use of'.
Zitzmann continues:

'Already in the court tapestry workshop one was concerned to maintain the fabrics in castles for as long as possible. From this tradition stems the re-use of textile pieces from torn curtains and wall coverings for furniture, the changes to cut, infilling of damaged points with surviving remnants or new fabric. An old method is also to glue silk weaves with starch onto a support fabric'.

Zitzmann then presents two examples: the first is an 'Example of glueing wall coverings with starch in the bed and workroom at Sanssouci.[4]

'In the castles of Sanssouci we find many top covers, wall coverings, embroidered fire-guards and even curtains, glued with starch onto a support (protective) fabric. The positive benefit of this adhesive method is met above all in the wall coverings. In the Castle Orangery, for example, we can attribute (thank) this method for the survival of the original silk coverings .... All these glueings would have been carried out before 1955. These methods have only just been seized upon again.'

Zitzmann records that the following recipe was employed:

250ml distilled water
70ml 70 alcohol
27g potato starch
0.6g natriumpentachlorphenol (fungicide)

She describes the method of past manufacture as follows:

'Water and starch (are) mixed, heated with a water bath to 80-90°C and stirred; finally the cold alcohol was stirred in and the glue used immediately.'

Zitzmann states that the 'added fungicide will not be used again because of its poisonous quality. The occurrence of mould on glued silks in the castle rooms is only encountered in rare and specific cases so we can forego chemical additives. Apparently the use of an underlay of three layers (linen fabric, paper and thick cotton felt), as is usual in the castles of Sanssouci, is effective against fungal attack.'

Zitzmann explains the method of adhering the wall coverings. 'The silk covering to be glued is removed (from the wall) and the underlayer is renewed or made good. Over this is stretched a single-coloured fabric, onto which the silk is glued. Cotton support fabrics have proved themselves .... Glueings on cotton are firmer than on silk fabrics. Apart from this, the sheen of silk support fabrics makes the damaged parts more prominent ... In order to be able to secure the glueing of large areas, the fabric can be divided and put together later. Seam allowances should be cut away otherwise they press through and form depression cavities. In preparing the silk to be glued it must be lightly dampened, because otherwise small folds can arise.'

'The ready-prepared, cleaned damask is rolled on a card roller, which is fastened so ... it can be lowered down in stages. The process is begun at the top when the fresh, stirred, warm paste is spread section by section on the support fabric and the damask is laid on top ... The large missing areas ... are covered with damask pieces from stock. The glueing of the wall coverings gives stability and support to the fragile woven silk. Damaged parts are closed, but remain visible.'

Conclusion
The starch paste treatment outlined above is illustrated with two photographs: one taken before a starch paste treatment and one taken afterwards. It is hard to assess either the effectiveness or the appropriateness of the treatment from these black and white prints. However, the use of 'damask pieces from stock' to infill large missing areas is evident, as the ivy and wheat design of the damask patch does not match the swags and butterflies of the treated damask.

The starch paste treatment of textiles at Sanssouci spans more than forty years and is well documented, as evidenced by this exhibition catalogue. This work provides a potentially useful source for monitoring the pros and cons of using starch paste to adhere furnishing textiles on open display.

It is important to note that the value of this work does not lie in a single case example. 'Textile treasures preserved at Sanssouci' provides a good introduction to a fine collection of eighteenth and nineteenth century furnishing textiles. It is also a useful model of how to document the process and rationale of presenting textile furnishings in period rooms.

In highlighting a single case history it is hoped that the work of Christa Zitzmann and her colleagues has been represented fairly and that there will be an opportunity for discussion with them before too long.

Health and Safety
Pentachlorophenol (C_6Cl_5OH) is too toxic for general use. As a pure chemical, it is not an approved pesticide under the United Kingdom's 1986 Pesticide Regulations.[5]

Alcohol is a general term; in this case it may refer to a 70:30 solution of ethanol and water. Exposure to ethanol may increase the toxicity of other inhaled, absorbed or ingested agents. It irritates mucous membranes, can cause headaches, dizziness, nausea at very high concentrations. It is an experimental tumorigen and teratogen.[6]

Ethanol should be used in a fume cupboard, handled with gloves; contact lenses should not be worn.[7]

Acknowledgements
Thanks are due to my colleagues Mary Brooks, for advice on this text, Alexandra Clarke, Janet Farnsworth, Alison Lister and Doreen Rockliff for advice on the presentation made on 2.11.94. I am also grateful to Nell Hoare, Director of the Textile Conservation Centre, for encouragement and permission to publish; to Klaudia Pontz for help with the English translation of the catalogue and to Jane Jeffery for preparing the text for publication.

References

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6 Clydesdale (1990) ***op cit.***
7 Clydesdale (1990) ***op cit.***

THE REPAIR OF TEXTILES USING STARCH AND CELLULOSE-BASED ADHESIVES

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Introduction

This paper presents a number of uses of Japanese paper with starch and cellulose-based adhesives for repairing fragile textiles. Four methods are used successfully in the Department of Conservation's Organic Materials Section: fine twists of paper to bridge tears; small, adhesive-saturated fragments of paper inserted between separating layers; pieces of paper to back damaged areas; and complete backings with paper.

The adhesives can be used wet, either full strength (as prepared) or diluted to the required consistency with the appropriate solvent.

Two object case histories will be described, in which one or more repair method was used. The versatility of the techniques is highlighted.

Case Histories

In past years, a considerable amount of work has been done with starch and cellulose-based adhesives and Japanese paper repairs.[1] The following treatments illustrate the usefulness of Japanese paper and adhesive where it is not possible or desirable to attach backings by stitching or heat-activated adhesive due to the poor condition of the objects.

1. Linen textile strip, wrapped around an Egyptian kohl tube

(Department of Egyptian Antiquities, BM Inventory Number EA 2579)
The kohl tube is made from a hollow section of reed and is of New Kingdom date, approximately 1650-1070 BC. It measures 9.5cm in length, has an overall diameter of 1.6cm, and was mounted, probably earlier this century, on a 2.6cm cube of wood. The linen textile wrapped around the tube was extremely degraded and brittle, with numerous tears and holes. The strip was separated into three sections by complete breaks.

To arrest further disintegration, it was necessary to join and secure the textile fragments. Repair using a backing attached by stitching or heat-activated adhesive would have involved more handling than was thought to be desirable. In addition, these methods would have required prior flattening of the textile which was considered to be inappropriate. Therefore it was decided to use Japanese paper and sodium alginate-arrowroot starch paste; initial experiment with the method on a small area proved to be effective.

A piece of *kozo* (mulberry) paper was given a graduated wash of watercolour to match the various shades of the textile.[2] When dry, the coloured paper was water-torn into thin strips, which were twisted to a similar thickness of the yarn from which the textile was woven. With minimum handling of the textile strip, the damaged areas were realigned and joined or secured as necessary, using the paper twists and sodium alginate-arrowroot starch paste. Strong and flexible, with a high degree of tack, sodium alginate-arrowroot starch paste has proved in tests to have superior ageing properties to gluten-free wheat starch paste.[3] The preparation of sodium alginate-arrowroot starch paste is described fully in the paper by Barbara Wills in this publication. The Japanese paper sutures were applied to the front of the textile. Two particularly vulnerable areas along the length were given additional reinforcement with small pieces of coloured paper and sodium alginate-arrowroot starch paste applied to the back.

Stability of the object was greatly improved by treatment, allowing careful handling and safe transport back to the Department of Egyptian Antiquities for storage. The method described was found to be extremely useful where a textile is associated with a three-dimensional object. An additional advantage is the relative ease of reversibility of the repairs in water.

2. Egyptian mummy, cartonnage cover and mask

(Department of Egyptian Antiquities, BM Inventory Number EA 6679)
The mummy consists of a body covered with a black, shiny layer, and linen wrappings. The black coating was analysed by Fourier transform infra-red spectroscopy by the Conservation Research Section, and found to be similar to pitch.[4] It was applied in ancient times to aid preservation. The body is covered by a cartonnage mummyform case and separate mask, which are elaborately painted. The object dates to the early Ptolemaic period, approximately 250-200 BC.

When first brought to the laboratory for treatment, the cartonnage was structurally very weak: torn and misshapen, with loose fragments and missing areas. The paint layer was cracked and lifting in areas. The linen mummy wrappings, where exposed through damaged areas, were dusty.

Full details of the conservation of the whole ensemble form the basis of a forthcoming paper. Treatment of the linen wrappings only will be described here.

To facilitate detailed examination and treatment, it was necessary to remove the cartonnage cover and mask. After temporary reinforcement using *kozo* paper and 1% (w/v) Klucel G (hydroxypropyl cellulose)[5] in IMS (industrial methylated spirit) the cover and mask were carefully transferred onto previously prepared supports. The linen wrappings were revealed to be loose and torn, and the underlying layer of pitch was fragmentary in many areas.

The linen textile was surface cleaned with a soft brush and low-powered vacuum suction. It was decided that repair by adhesion was preferable to stitching. Due to the fragile condition of the textile, manipulation with a needle and the cutting action of thread were likely to cause further damage. Where torn and loose, the linen wrappings were secured with pieces of *kozo* paper, made into thin twists, adhered in place with sodium alginate-arrowroot starch paste.

For minor repairs, sodium alginate-arrowroot starch paste was applied to the underside of the loose textile with a small metal spatula. Where stronger adhesion was required, 10% Blanose 7MC (carboxymethyl cellulose) in distilled water was used, especially for securing loose fragments of pitch. Small pieces of Japanese paper, saturated with adhesive, were inserted between layers of textile wrappings and delaminating areas of pitch using fine-pointed tweezers. Areas of repair were held in place or weighted until dry.

Treatment restored the object to a stable condition, enabling it to be displayed in the gallery. Again, Japanese paper and adhesive repairs proved very useful on fragile textile which is an integral part of a three-dimensional object.

Conclusion

In the two case histories described above, the versatility of Japanese paper was demonstrated in its use as a support and repair material. The fine texture and lightness of the paper were necessary for compatibility with the fragile, ancient textile being treated. Starch and cellulose-based adhesives provide the requisite strength and flexibility of the repairs, while retaining reversibility. Stability of the objects was significantly increased after treatment.

Health and Safety

The adhesives used in the treatment described in this paper are of low toxicity. COSHH regulations should be observed when handling solvents.

Acknowledgements

I would like to thank Dr Andrew Oddy, Dr Vincent Daniels and Allyson Rae for their advice; David Thickett and Yvonne Shashoua of the Conservation Research Section for their analytical work and everyone involved in the work on the cartonnage project.

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4 Thickett, D, Analysis of materials from Egyptian mummy EA 6679, ***British Museum Conservation Research Section Report***, No CA 1991/6.
5 Daniels, V D, Report on the investigation of Cellofas B, Ethulose, Klucel L, Klucel G and wheat starch for use as consolidants/adhesives for organic materials, ***British Museum Conservation Research Section Report***, (1983).

Materials and Suppliers

Acrylic paints
G Rowney & Co Ltd
12 Percy Street
London W1, UK
0171 636 8241

Arrowroot starch
Any pharmacist

Blanose 7MC
Aqualon (UK) Ltd
Genesis Centre
Garretfield
Birchwood
Warrington WA3 7BH, UK

Goretex
W L Gore & Associates
Museum Products
P O Box 1550
Elkton
MD 21921, USA

Japanese papers
Falkiner Fine Arts Ltd
26 Southampton Row
London WC1, UK
0171 831 1151

Klucel G
Aqualon (UK) Ltd

Melinex
Hi-fi Industrial Films Ltd
Gunnels Wood Industrial Estate
3 Babbage Road
Stevenage
Hertfordshire S91 2EQ, UK

Merck indicator strips
Merck Ltd (BDH)
P O Box 11
Freshwater Road
Dagenham
Essex RM8 1QF, UK
0181 599 5141

Sodium alginate
Merck Ltd (BDH)

Watercolours
Winsor & Newton
12 Rathbone Place
London WC1, UK

PERSONAL EXPERIENCE OF THE USE OF STARCH PASTE DURING THE LAST HALF CENTURY

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During the early period of my life, wheat starch paste was in common use for wallpaper hanging and paper crafts. Brands such as Lap and Stadex were sold partly prepared and mixed easily with cold water. Otherwise culinary flour was used for reasons of economy, or, as during World War II, scarcity.

Culinary (plain) flour paste was made by blending flour with as little cold water as necessary to make it liquid. Onto this, boiling water was poured whilst stirring hard until it turned from white to translucent grey as the starch grains burst with the heat and formed a colloidal solution. The basic paste was thinned with cold water.

My reason for mentioning this is that, in my childhood scrapbooks, the flour paste has not yellowed and the primary school papier maché work has not come unstuck.

My experience of making up starch paste was extended to laundry starch in the 1950s, due partly to tradition, and partly to the demands of fashion. Laundry starch is required to give a solution that will penetrate cotton and linen fabric well, but leave it pliable, giving a smooth, dirt resistant surface. Most commercial starches are blended, and usually include borax, an alkali, to increase viscosity. Rice starch is best for this purpose, giving sufficient stiffness with pliability; wheat starch gives a stronger viscous solution, is stiffer and more difficult to remove. It is used now in liquid starches. Maize is stronger still, the cheapest, and is the laundry starch sold by Boots today.

Laundry starch is made by the same method as I have described for culinary wheat flour paste adhesive, but more dilute to act as a fabric filler. The proportions are: 1 tablespoon starch blended with 2 of water, with 1 pint of boiling water poured on, diluted, with cold water, for example 1:4 for table linen or 1:8 for underwear and blouses.

Until the 1960s cold water starch was still employed for dress shirt fronts and collars and nurses' uniform caps. 1 ounce of starch blended with half a pint of cold water was rubbed evenly into the fabric using the knuckles and palms of the hands. The application of a flat iron or goffering iron, well heated, sanded clean, and beeswaxed for slip, burst the starch grains making it very smooth and stiff.

So when, as a conservator, encouraged by a curator to use starch paste adhesive because it is not reactive, the preparation presented little problem, but the consistency did. Too wet a sample distorted thin textiles and was as ineffective in securing metal braids to boxes as I had found carboxy methyl cellulose to be.

CMC, though transparent in solution, easily causes staining to the fabric when it is not clean, and its penetration of fine silk is too great. Its bonding is not effective with heavy materials, for example metal braid.

Most of the large range of commercially available poly vinyl alcohol or acetate adhesives are open to question, because of the danger of yellowing and the question of reversibility. On some objects, Vinamul 6815 and Mowilith DMC2 were apparently effective but not as controllable to use as the starch paste.

From my observation on 17th century raised work caskets in particular, starch paste was used. On 19th century objects where traditionally animal glue has been used, that is by brushing while hot onto wood, prior to the textile being laid down immediately, there is usually no penetration. This glue layer can be re-activated by moisture, and to a certain extent starch paste will do this. I have found this a satisfactory method.

A convenient method for making small quantities of rice or wheat starch employed by me for conservation is to blend 25 gm BDH Merck starch with 25 ml cold de-ionised water in a stainless steel vessel, pour into this 75 ml boiling water stirring well, then reheat. Once the mixture has reached the point of glutinisation, stop and beat until smooth. This is a very stiff consistency which dryness prevents ring staining, and whose use I am to demonstrate, but for other work it may be thinned with cold water. It is usable over a period of at least a week if stored in a refrigerator.

A small curved metal spatula, Tiranti No 46, controls application to small areas such as metal braids. An artists' stiff flat brush is effective in spreading a fairly dry paste over wood preparatory to laying the textile down onto it. Pressure may need to be applied.

My trials of both wheat and rice starch on one object requiring extensive conservation of loose silver gilt braid, showed wheat starch to be the stronger.

Wheat starch paste used in this dry consistency has been effective in sticking silver braids on 17th century raised work caskets; light coloured moire silk covering 18th century geological specimen cases; green wool baize lining and a base, and silk velvet linings to both 18th century medical resuscitation boxes and a 19th century writing box.

POSTER:
CONSERVATION OF A *PANG KHEBS*

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(This article first appeared in the V&A Conservation Journal, 12 (July 1994) and is reproduced by kind permission of the Trustees of the V&A.)

In 1905 the South Kensington Art Museum, as the V&A was then called, was given a portion of a masker's costume from the Himalayan district of Sikkim. The gift consisted of a robe, collar, apron (*pang khebs*), hat and boots, reputedly worn by a Sikkimese lama in 'The Mystery Play' (*Tag-mar-ch'am*).

The costume showed heavy Tibetan influence, particularly the apron where the decoration was achieved by appliqué work, a typically Tibetan technique used mainly for religious textiles. Aprons of this kind are often seen in early photographs of Tibet showing the 'Black Hat' dance performed as part of the New Year celebrations. The designs are usually similar to the one being discussed here, only varying slightly in colour but always worked using the same appliqué technique. Tibetan appliqué work has, to date, been little researched. It does however warrant study because it uses techniques and materials intrinsic to Tibet, which even today in the late twentieth century is still relatively inaccessible to the general Western public.

The main body of the apron (measuring 86cm high x 77.5cm wide) is simply constructed from three pieces of silk and cotton union twill. The design portrays a *Khro rgyal*, a wrathful protector of religion surrounded by sacred thunderbolts (*dorje*) symbolically depicting the indestructible aspect of the enlightened mind, heads of ghouls (*tur*) and fierce deities (*t'o-wo*); these latter two reminding the viewer of the transience of existence.

Like patchwork and appliqué textiles in Europe which are made from left over pieces of fabric, Tibetan appliqué also appears to have used this criteria. Numerous weave types were used on this particular apron, ranging from plain weave, twill and satin to damask and brocade utilising silvered paper lamellas.[1] Black ink outlines were visible on many of the motifs indicating how the design would have been mapped out prior to cutting. Raw edges were 'stopped' with a paste and these edges were then either turned underneath or concealed with bias cut strips sewn over the top. The *khro rgyal's* three eyes were interlined with a thick yellow paper to give them extra body and stiffness. The fire-like whiskers and eyebrows were of gilded leather which proved to be alum tawed with a varnished silver surface.[2] The other interesting discovery was the use of yak (Bos grunniens) hair in the gimp (a thick cord-like thread) outlining many of the design elements.[3]

Structurally the apron was sound. However damage had been sustained probably through wear when the dancer, in a state of semi-trance, would have whirled around raising and lowering his arms, thus brushing his voluminous sleeves against his apron, resulting in lifting and delamination of the silvered paper lamellas in the outer border. One corner of this border was particularly damaged, caused by stress and abrasion received when the apron was secured around the wearer's waist. Folding the apron in half for storage had also caused a strong disfiguring crease through the central eye (accentuated by the thick paper) and flame whiskers below the demon's mouth.

A fairly passive approach was taken over the conservation, mainly due to the mixed media used in the construction of the apron. Lessening the severe crease was achieved by cold poultice which involves placing the textile over damp cloths and a further dry cloth used as an isolating layer; a sheet of polythene placed on top allows the textile to relax in the resulting humid conditions. The textile is then pinned under tension over the cloths and left until they are dry.

The outer border was treated using 5% Klucel G (hydroxypropyl cellulose) in ethanol to lay both lifting and delaminating lamellas back into position. A non-aqueous adhesive was chosen to reduce the likelihood of any possible staining and weakening of the paper and for speed of drying. Although the paper was originally woven into the fabric, the more common conservation technique of stitching was not appropriate for this treatment and in order to stabilise the lamellas an adhesive treatment was used. Any movement after adhesion would again result in lifting of the lamellas, therefore the chosen method of display needed to be integral with the conservation, giving permanent support to the entire apron. This entailed mounting it onto a flat padded board which to a certain extent has diminished the apron's visual impact now it is viewed out of context. Hopefully, however, at some future date the remaining items of the ensemble will be conserved and the apron's static display re-examined.

References

1 Lamella is a flat strip of precious or base metal or of gilt or silver membrane, leather or paper used for yarn. It may be used flat or wound around a core.
2 Analysis by the Leather Conservation Centre, Northampton.
3 Analysis by Jo Darrah, Conservation Science Group, V&A.

POSTER:
THE PRACTICAL CONSERVATION OF A PAINTED AND EMBROIDERED SILK PICTURE

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Introduction

The picture dates from the early 19th century. It is the property of a private collector and is one of a pair that were conserved in May 1993. The topic of the picture is biblical and it shows Abraham casting out Hagar and Ishmael into the wilderness, with Sarah looking on. The picture is made up of three different layers of fabrics, a linen backing covered with a fine painted silk, and over part of this is heavy wool and chenille embroidery. The picture shows some of the typical conservation problems found in these painted and embroidered silk pictures.

The woollen embroidery was probably carried out rather tightly in the first instance, then it was stretched, but the wool has shrunk back again. The silk is degraded, fragile and powdery, and large pieces are missing. There are different tensions between the materials and the buckling of the fabrics has caused the silk to break up. Paints had been used to restore the holes in the silk in the past. There are holes in the embroidery and the associated moth cases.

This textile came to the workshop partly attached to a card backing board, one side of which was covered in an animal glue. This backing was very sensitive to changes in humidity.

Preparation for Conservation

The textile was removed from the backing and gently vacuumed. Tests showed that it could not be wet cleaned and that the soiling would not be removed by dry cleaning. Tests were also carried out to find a suitable solvent for the adhesive to be used in the conservation treatment.

The curled edges and the woollen embroidery were relaxed by means of contact humidification on layers of moistened acid-free blotting paper.

A support fabric of scoured calico was attached to an embroidery frame and secured at the edges with cotton tape. A thick foam board was placed at the back of this new fabric so that the materials could be kept flat, stable and pinned in place during conservation.

Conservation

Shaded dyeing of the backing fabric

The painted silk was basically a khaki colour, with a landscape, sky and clouds painted on it. Habutai silk was dyed to blend with the background colour of the old fabric. The new fabric was dyed using 1:2 metal complex Lanaset dyes produced by Ciba Geigy. A 1.1% depth of shade achieved the desired colour of khaki; the dyeing process was completed and the fabric was dried.

Experiments were carried out using fabric paints to blend the colour changes in the sky on the modern silk. As a non-painter the results of painting were rather clumsy and the visual quality of the silk was affected by the pigments. Over-dyeing was selected as a treatment. Further experiments were carried out masking the fabric that was not required to take up the blue and immersing the whole piece, but this gave harsh lines.

The habutai silk was over-dyed with a 0.19% blue; the corner of the fabric was positioned in the new bath and gradually removed completely. Capillarity and agitation helped to create a softened edge to the blue. It was important to have two separate dye baths, otherwise the blue became very brown. Whilst this was a dip dyeing process at the corner of the fabric, the full dye procedure was completed for all areas of the blue, so that there would not be additional problems with the light fastness. This gave an effective gentle colour change but it did not recreate the appearance of the sky with the clouds in it.

Dyeing the overlay fabric

Silk crepeline was dyed to a 0.1% depth of shade to match the backing fabric. A pale shade was selected to allow for yellowing of the adhesive with age, as discussed by Feller and Wilt in their research work 'Evaluation of Cellulose Ethers for Conservation' produced by the Getty Conservation Institute in 1990.

Cutting out and inserting the backing fabric

A clear polyester film of Melinex was laid over the picture and the outline of the silk area was marked using a Chinagraph pencil. The pattern was cut out, the dyed silk marked up with a pencil, and this was also cut out.

The new silk was inserted behind the remaining painted silk, using fine metal spatulas, probes and slivers of Melinex. The fragments from the bag of loose bits that were received with the textile could then be positioned like a jigsaw. The painted silk went to the outer edge of the picture on two sides so it had two unsecured edges and it was possible to insert the new fabric from these sides. The tiny fragments had a tendency to move so this sandwich was held in place by glass weights.

Coating the silk crepeline with adhesive
The silk crepeline was laid out on Melinex, and de-mineralised water was used to align the warp and weft of the fabric. The water also kept the silk in place on the Melinex. The adhesive Klucel G, hydroxypropyl cellulose, was made up to a 5% solution in the organic solvent IMS, which is a mixture of ethanol and methanol. Using a brush, this was applied onto the fabric then laid off to give an even coat by brushing along the warp and weft. This was allowed to evaporate, using fume extraction throughout the procedure.

Positioning the fabric with the adhesive film
The silk crepeline was laid out over the original silk. This fabric and adhesive film is very highly statically charged and has a tendency to attach itself to itself. An edge of the coated fabric was aligned with the fragile silk and entomological pins were put at right angles to the picture to hold the layers of fabrics in place. The Melinex was peeled back gradually, and the glass weights were removed one at a time. Pinning would have damaged the fragile painted silk so this was avoided.

Cutting the edges of the silk crepeline
The edge of the silk crepeline was cut so that it went exactly to the edges of the embroidery. Scissors were used for part of the process but it was most effective to cut the crepeline thread by thread, using a scalpel, with the blade facing away from the object.

Bonding
Experiments with spray activation of the adhesive showed that it did not produce a good bond, but brushing on the solvent was more effective. A second attempt at brushing solvent onto the same adhesive coated crepeline ensured that all the Klucel G moved from the crepeline so it did not adhere at all. Experimentation also showed that when the adhesive was applied by brush directly onto the test piece it caused staining. The conclusion was that it had to be a one step treatment.

The solvent IMS was painted on by brush. The fabrics were held together with the entomological pins and the brush action increased the contact between the fabrics. This was left to evaporate thoroughly. The adhesive only bonded the silk crepeline overlay, and to the layer of silk immediately below it. Nothing became adhered to the linen.

Restoration
The sky was restored in appearance by inserting a new silk, dyed blue with Ciba Geigy Lanaset dyes, underneath the original silk. The restoration work is separate to the conservation work but it cannot simply be removed. The woollen embroidery was not restored.

Conservation stitching
On completion of the conservation of the painted silk, the foam board was removed from behind the embroidery frame. The textile was held in place on the scoured calico support with running stitches in a fine polyester mono-filament thread. Pockets or shelves for the fragments of painted silk were made by stitching around each of the pieces. This stitching was in a finer polyester thread drawn from the filtration fabric, Stabiltex. For this project the use of some stitching was important otherwise the silk overlay is being supported by the degraded silk that it is consolidating. All the stitching was carried out through the silk crepeline, modern habutai silk, the linen and calico. No stitches were put into the painted silk. The loose woollen embroidery threads were stitched in place.

The edges of the fabrics which were concealed behind the frame were covered with a fine nylon tulle, which was stitched in place.

Making up a Mount Board
Acid free rag card was used as the mount board. This is a support and adds cellulosic materials to the object so that it performs some buffering against fluctuations in the humidity inside the frame. This is particularly important for this type of adhesive because of problems with it reversing in a high humidity, and also the textile belongs in a private house with no other environmental controls. The card was covered with a layer of cotton bump which was wrapped around the edges. The corners of the bump were mitred and stitched and the fabric was held in place at the back with a paste of the high viscosity sodium salt carboxymethyl cellulose made up to 3% in softened water. Finally the board was covered with a layer of scoured calico which was also mitred at the corners, stitched and adhered to the cardboard. The raw edge of the calico at the back of the board was neatened by covering it with archival tape; this is made up of a calendered linen coated on one side with a water soluble starch adhesive.

Completing the conservation
The conserved embroidery was pinned onto the board and stitched through the calico and bump. The corners were finished in the same way as they had been when the textile was received.

The inside of the frame was cleaned. An acid free card sub-frame was cut to sit behind the gilded fillet. The glass was not in the frame when it was received so this was replaced with Tru Vue Conservation Clear glass, which has an ultraviolet filter painted onto it and this has the benefit of not appearing as flat as modern glass. The inside of the glass and frame were sealed with archival tape. The back of the frame was built out with acid free card to take the increased depth of the embroidery and sub-frame. The textile was pinned into the frame; then a cover of acid free card was placed over the back and held in place with archival linen tape.

The rings and wire forming the hanging system were renewed.

Conclusions
The testing, experimentation and preparation of the silks took a long time but the activation of the adhesive and bonding process is very rapid. The results were good and the client was pleased. The silk appears to have an even support and this is not lessened at the edges. The cellulosic materials of the mount board act as buffering against changes in the humidity, but the bonded fabrics may create internal stresses.

The painted silk was very fragile; it was not possible to insert the underlay right to the edge of the embroidery. The painted silk is not opaque, so the colour of the new underlying habutai silk affects the overall appearance. This can be seen at the edges of the embroidery and this was the least satisfactory part of the treatment. The silk of the second picture was denser and this was not a problem.

Problems of the S-CMC failing at the back of the mount board may raise some concerns of leaving the fabrics loose, making this unsuitable for large textiles, but it was quick and effective for this project.

The conservation of the two embroideries formed a two week practical project. I have not discussed the selection of Klucel G or the technical problems with the adhesive as these were discussed by Carla Petschek in her paper presented at the UKIC Adhesives Forum in June 1993, which is included in this publication.

Suppliers
Klucel G / silk crepeline
Insta Business Services
P O Box 41
Liss
Hampshire GU33 7PT, UK

Carboxymethyl cellulose sodium salt (High viscosity)
Analytical Supplies Limited
Duffield Road
Little Eaton
Derby DE2 5DR, UK

Arichival quality blotting paper
Fairway Business Supplies
Unit 11, Carlton Phoenix Estate
Kilton Road
Worksop S80 2EE, UK

Calico / Habutai silk / Bump
Whaleys (Bradford) Ltd
Harris Court, Great Horton
Bradford
West Yorkshire, BD7 4EQ

Entomological pins Size 0 and 00
Watkins and Doncaster
P O Box 5
Cranbrook
Kent TN18 5EZ, UK

Acid free rag card / Archival linen tape / Melinex
Atlantis European Ltd
146 Brick Lane
London E1 6RU, UK

Nylon tulle 20:20 denier
Dukeries Textiles and Fancy Goods Ltd
Fearfield Buildings
4 Broadway (off Stoney Street), Lace Market
Nottingham NG1 6FF, UK

Polyester Skala thread
Perivale-Gutermann Ltd
Wadsworth
Greenford
Middlesex UB6 7JS, UK

Tru Vue conservation clear glass
Glass and Mirror
Brook Way
Leatherhead
Surrey KT22 7AN, UK

POSTER:

AN INNOVATIVE COLD-LINING TECHNIQUE: THE CONSERVATION OF THE SHROUD OF RESTI

PIPPA CRUICKSHANK and HELEN MORGAN, Department of Conservation, The British Museum, London WC1B 3DG, UK

Introduction

The Shroud of Resti is very rare, being one of only nine Ancient Egyptian linen 'Books of the Dead' painted with texts and vignettes known to have survived. The British Museum is fortunate in possessing three of these shrouds, which all date to the New Kingdom, 18th Dynasty, c. 1450 BC. Examples on linen shrouds are amongst the earliest 'Books of the Dead'. Papyrus was most commonly used and continued in use for a much longer period.

The term 'Book of the Dead' was chosen by modern Egyptologists to denote a collection of magical texts and vignettes, divided into spells or chapters, which the ancient Egyptians placed in coffins with their dead to secure their safe deliverance into the afterlife. Whilst papyrus examples would have been rolled up and placed alongside the body in the coffin, it is thought that those on linen would have formed the final shroud covering of the mummy and be placed over the cartonnage.

Description

On arrival in the laboratory of the Organic Materials Conservation Section it was unclear how much of the shroud had survived. The textile fragments were very disorganised and crumpled, being folded and tangled together. The linen was very degraded and extremely vulnerable with fibres shattering very easily when touched. There were many tiny powdery fragments.

An initial humidification process was carried out in order to straighten the textile fragments sufficiently to ascertain what remained. The fragments could then be aligned and positioned using the weave and text as a guide. It was discovered that the fourteen larger pieces remaining could be joined together and grouped into four main sections. A large portion of the centre of the shroud was, unfortunately, found to be missing. It is thought this may have been cut away either due to severe damage, or perhaps in order to sell as a separate object. It was pleasing that although the shroud was so fragmentary, sections of all four edges remained. The two selvedges, warp starting edge and warp fringe are all typical of New Kingdom textiles.

The textile was particularly brittle in areas which were discoloured by what appeared to be body decomposition products. The fringe end of the shroud was heavily soaked with resinous, blackened deposits making the linen very rigid. The warp fringes were brittle and fused together. Areas that were painted tended to be friable and cracked, the pigment only loosely attached to the fibre surface. The colours, however, appeared remarkably fresh and unfaded. Analysis of the pigments was carried out by Lorna Green and David Thickett of the Conservation Research Section of the British Museum.[1]

The cursive hieroglyphics of the 'Books of the Dead' are predominantly written in black, the beginning of each spell and more important passages being in red. The columns are divided with black lines, some of which are highlighted in yellow. The text is divided with three broad horizontal registers with yellow and blue decorative hieroglyphic bands. On the left side is an image of Resti, the lady who owned the shroud. The vignettes are all highly coloured and, like the text, of high quality.

Choice of Treatment

It was apparent that a rigid backing support would be essential for the future safe-keeping of the textile to prevent flexing of the linen and vulnerable paint surface. It was decided to line the shroud in the four main sections that the remaining fragments naturally formed. None of these sections could be joined directly to another due to missing portions of the shroud. In addition, storage and display possibilities would be greater than if the shroud were mounted on one huge board.

The severe embrittlement of the fibres and the presence of pigment meant that stitching the fragments to a support fabric would be likely to cause further damage. An adhesive method seemed the best alternative. A wet drop-lining technique was eliminated as it would have involved turning the painted side of the textile face down and the use of relatively high moisture levels which might have caused staining of the linen.

Thermoplastic resins have previously been used to line Egyptian pigmented textiles.[2,3] However, it was felt that the high temperatures required would be too damaging for such a fragile object. In addition, when heat-sealing, silk crepeline or a similar fabric is generally used which seemed an unsuitable lining material as it is chemically and texturally different from the linen. It would also have been virtually impossible, due to the extremely fragmentary state of the textile, to avoid some areas of shiny exposed adhesive around the periphery of the ancient linen which would have been unsightly and liable to attract dust. Previous work on an ethnographic banana fibre belt had shown that the reactivation of adhesive-coated paper backings provided a versatile method for mounting cellulosic artifacts.[4] With the use of a vacuum table, the papers could be reactivated and adhered to the textile in one process, thus eliminating excess handling and allowing the vulnerable painted surface to remain uppermost at all times.

Scientific tests were carried out by Yvonne Shashoua of the Conservation Research Section to determine the least damaging lining treatment for the shroud. Fragments of ancient linen that had been subjected to a heat-sealing cycle on a vacuum table were examined for evidence of mechanical damage using a scanning electron microscope and the results compared with untreated linen control samples and those which had been subjected to the conditions of moisture, pressure and low temperatures of cold-lining. The results suggested that a cold-lining technique was less damaging than those involving heat and higher pressure.[5]

Conservation

Following extensive preliminary tests, a procedure was carried out which drew on the earlier conservation of a banana fibre belt.[4] Since the proposed treatment involved the use of humidification techniques, it was important to ascertain whether any water-soluble binder was present. Yvonne Shashoua analysed colouring material samples, but found no trace of binder within the detection limits of FTIR spectrometry.[6]

In order to enable the fragments to be sorted and correctly positioned they were gradually humidified in a controlled humidity chamber over a period of five days to raise the relative humidity from 60% to 80% before returning it to 60%. As the fibres relaxed, creases were eased out and the textile gradually reshaped and held in position with glass weights. The heavily creased, rigid area at the warp fringe end of the shroud needed additional relaxation using an ultrasonic humidifier.

The friable pigments were consolidated with 2.5% Paraloid B72 (ethyl methacrylate copolymer) in xylene using a fine sable brush. Paraloid B72 was chosen as a reliable resin with good ageing properties, low sheen and lasting flexibility and a record of previous successful use on Egyptian pigments.[2,3]

The four sections of the shroud to be mounted were treated separately. Each section was returned to the humidity cabinet and prepared for the vacuum table treatment by gradually conditioning the textile to 90% RH. The textile was pinned out with entomological pins onto layers of thick Plastazote (polyethylene) foam covered with thin Melinex (polyester) film until the fragments and text were fully aligned. On the evening prior to treatment, the pins were carefully removed and a layer of Goretex (polytetrafluoro ethylene / polyester laminate) was carefully rolled over the relaxed textile, the smooth surface against the linen. This layer kept the aligned textile in place and also provided a permeable layer to allow further moisture to impregnate the fibres without the risk of excess wetting out. The Goretex was weighted around the edges, avoiding the textile beneath. The cabinet was set to 85% overnight and raised to 90% in the morning in preparation for lining on the vacuum table.

Sheets of Japanese mulberry paper, *kuranoi*, were pasted out using a brush onto thick Melinex sheets with a 75:25 solution of 3% w/v Blanose 7MC (sodium carboxymethyl cellulose) : 3% w/v arrowroot starch adhesive in distilled water. *Kuranoi* was chosen because of its long mulberry fibres which impart wet strength and its dimensional stability when wetted out. Tests confirmed that there was no shrinkage on drying. Its matt, off-white appearance is visually sympathetic to the linen. The adhesive chosen gave a good bond without excess sheen[4] and tests had shown it to be flexible, colourless and to have good ageing properties. It was also easy to prepare and handle. When the papers were dry the prepared sheets were removed from the Melinex by releasing the edges with the aid of a spatula knife and then pulling evenly from one edge. They were temporarily joined prior to the vacuum table treatment by spotting an overlap of 1.5cm with the same adhesive and weighting the joins overnight. Thus four large areas of backing paper were prepared to the required dimensions for each textile section.

The large sheet of backing paper, its 'shiny', adhesive-coated layer uppermost, was placed over an interlayer of thick Bondina (non-woven polyester) on the vacuum table's perforated screen. The table was left uncovered and pre-warmed to 32°C. Distilled water vapour was gradually introduced into the table, raising the humidity to 70%. At this stage the textile was transferred directly from the humidity cabinet (at 90%) to the vacuum table supported on a rigid board and sandwiched between thin Melinex and Goretex as previously described. The humidification of the textile, both preceding and during this process, was fundamental to the treatment's success.

The Goretex was very gently rolled off the textile, which still retained much of its absorbed water, and the textile was gradually eased off the Melinex and onto the conditioned adhesive-coated paper. This process was effected with the help of palette knives and blunt tweezers. As soon as the textile had been satisfactorily positioned on the paper, thin Bondina was rolled gently over its surface. A latex sheet was then rolled over the entire surface of the table, thus providing a complete seal.

The table temperature was kept at 32°C throughout the entire humidification / dehumidification process, which lasted two and a half hours. The relative humidity was gradually raised to 90% to reactivate the adhesive backing paper, at which point a maximum pressure of 36 millibars was applied for 15 minutes while the bond was made. The humidity was then gradually lowered to ambient levels. The pressure was gradually raised throughout the humidification process, and then lowered during the dehumidification process.

In order to preserve the innate qualities of the fringe and tassel and their three-dimensional appearance, they were protected from the adhesive coating on the backing paper during the cycle using an interleaf of thin Bondina. In this way they remained loose. The protection of particular areas of a textile in this way during cold-lining may be useful in future treatments.

Storage and Display
The shroud has now been successfully backed onto undyed mulberry paper. Being cellulose, this is chemically similar to the linen and visually it complements the Museum's collection of papyri mounted on neutral-coloured papers. Each of the four sections is supported on a backing board with a Plastazote window-mount cut to fit around the contours of the textile fragments to protect the vulnerable paint surfaces. The mounted objects are enclosed within transparent Melinex sleeves and stored in custom-made boxes to provide a dust and light-free environment. Correx, a lightweight (polypropylene) board was used as the backing board for the three smaller sections and to make the boxes. The largest section was supported on Aerolam F board (glass fibre, epoxy laminate on aluminium honeycomb) to provide additional rigidity.

Future display of the shroud will, unfortunately, be restricted due to the presence of the yellow pigment orpiment - an arsenic sulphide (As_2S_3) - which can fade to white on prolonged exposure to light.[1] However, the shroud is now readily accessible for study. For the first time the text may be read in its entirety, the fragments having been straightened, aligned and correctly positioned.

Safety Considerations
Most of the procedures described involve materials of little or no toxicity. The process of consolidation using an ethyl methacrylate copolymer in xylene should be carried out in a fume room or cupboard with full extraction, wearing a protective mask, gloves and overalls. Relevant COSHH procedures must be followed.

Acknowledgements
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Materials and Suppliers

Aerolam F boards
Ciba Geigy Plastics Ltd
Industrial Chemicals Division
Duxford
Cambridgeshire CB2 4XQ, UK

Arrowroot starch
Any pharmacist

Blanose 7MC
Aqualon (UK) Ltd
Genesis Centre
Garretfield, Birchwood
Warrington
Cheshire WA3 7BH, UK

Bondina
Atlantis European Ltd
146 Brick Lane
London E1 6RU, UK

Correx
Correx Plastics
Madleaze Industrial Estate
Bristol Road
Gloucester GL1 5SG, UK

Goretex
W L Gore & Associates
Museum Products
P O Box 1550
Elkton, MD 21921, U S A

Japanese mulberry paper 'kuranoi'
Falkiner Fine Papers Ltd
76 Southampton Row
London WC1, UK

Lascaux humidification chamber HC-5
Alois K Diethelm AG
Farbenfabrik
CH-8306 Brutiseuen
Switzerland

Latex rubber
Four D Rubber Co Ltd
Heanor Gate Industrial Estate
Heanor
Derbyshire DE75 7SF, UK

Willards low pressure vacuum table
Willards Developments
Industrial Estate
Chichester PO19 2TS, UK

Paraloid B72
Rohm & Haus (UK) Ltd
Lennig House
2 Mason's Avenue
Croydon CR9 3NB, UK

Xylene
BDH Chemicals
Broom Road
Poole
Dorset BH12 4NN, UK

Plastazote foam
Zote Foams Ltd
675 Mitchum Road
Croydon CRN 3AL, UK

Melinex sheet
Hifi Industrial films Ltd
Gunnells Wood Industrial Estate
3 Babbage Road
Stevenage
Herts S91 2EQ, UK

POSTER:
STEPS IN MAKING WHEAT STARCH PASTE, WITH TWO EXAMPLES OF USE

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Making Wheat Starch Paste

Ingredients
Wheat starch (BDH Chemicals Ltd)
Tap water

Method
1 Mix starch and water to a smooth paste. Since wheat is a plant, the quality is bound to be variable so proportions, too, are variable. The final mixture can always be diluted. The initial mixing is best done in a heavy saucepan using a wooden spoon.
2 Boiling water is stirred into the starch/water mixture until it turns glutinous.
3 The saucepan is placed over a low heat and the contents cooked gently, stirring all the time.
4 After 15 to 20 minutes the mixture will have thickened and become more glutinous.
5 It is poured into a terracotta vessel to cool.
6 When it is cold the mixture is pressed through a hair sieve.
7 The sieved paste is worked to a usable consistency with a brush. More water can be added.

Two Examples of the Use of Wheat Starch Paste

The Warner Pattern Books
The Warner Pattern Books are books of silk samples, the earliest of which dates from the mid-18th century. One of these books had lost most of its binding and the pages were very degraded.

Having removed the samples, each page was consolidated by attaching a layer of silk crepeline fabric to the back and front, using wheat starch paste. Card mounts with which to handle the pages were similarly attached around the edges of the silk and page.

The two layers of silk, the page and the two mounts were pasted out onto a perspex sheet with a layer of terylene fabric between them for easy release. The dry page was placed under pressure for two months, when the samples were reapplied.

The Melville Bed
The Melville Bed is a late 17th century state bed. The three base valances are suspended from carved wooden supports covered in silk velvet with the three-dimensional patterns outlined in silk braid. The velvet on these supports was coming unstuck and the braids were frequently loose or missing.

Wheat starch paste was used to reattach the velvet and braid. Cotton tape was dyed and used to replace missing braid and attached similarly.

References
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POSTER:
THE TREATMENT OF PAINTED AND EMBROIDERED PICTURES (KLUCEL Gee IT WORKS)

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Conservation Problems
The difficult conservation problems posed by painted and embroidered pictures are well known and have led to a variety of treatment approaches, many taken in the belief that the treatment will be the last the picture can withstand. These pictures are usually composed of a silk fabric over a linen backing with the areas of embroidery worked through both layers. The finer details are painted in watercolour onto the silk or drawn on gummed paper.

When these pictures are received for conservation they are often still nailed to their wooden stretchers and within glazed frames. It is also common for the frames to be in much less than perfect condition.

In most cases the silk requires stabilisation and access to its reverse is prevented by the presence of the linen backing. The embrittlement, splitting and fragmentation of the silk is usually due to a combination of light damage, the reaction to changes in ambient relative humidity and being mounted under tension. As linen has a greater ability than silk to gain and lose moisture from the air, tensions are created across the silk and damage occurs. Insect attack on wool embroidery and soiling from airborne pollutants entering through unsealed frames are also common problems.

A variety of treatments have been undertaken in the past in different studios. These have included: cutting the linen away to gain access to the reverse of the silk; cutting slits in the linen to allow adhesive impregnated patches to be inserted; slipping adhesive impregnated patches, or cast films, or sticky threads in from the front through splits in the silk. The adhesives used have been heat activated or applied in solution. It is generally agreed that stitching is not a treatment option for the degraded silk as it would be structurally damaging and visually disfiguring.[1]

This paper describes the approach taken and techniques used for the conservation of two painted and embroidered pictures treated in March 1991 at the Textile Conservation Centre. This work was presented at the Adhesives Forum I, 29 June, 1993.[2]

Treatment Choice
The pictures, which are privately owned, were acquired by the client's family between 1800-1820. They had been stored in an attic since c. 1940 and the client wished to have them conserved so that they could be hung and displayed in the family home. Both were still in their original glazed frames.

The first treated depicts a scene from the biblical story of Hagar and Ishmael. The foremost problem was a long split in the silk which divided the painted head of Hagar and then continued upwards through the sky exposing the light coloured linen backing. The painted limbs and Ishmael's slumped head also had numerous small holes caused by insect larvae varying their diet from the surrounding wool.

The primary aim of the conservation treatment was to secure the silk and prevent further loss. Covering the exposed linen and infilling obvious holed areas in the wool embroidery was considered important for aesthetic reasons.

It was felt that the action of inserting a support patch between the long split from the front would cause significant damage. The adhered patch would also introduce another area of stress leading to the probability that the silk would split around the edges of the patch. It is essential for any support patch to extend from a weak area into a strong area and it was difficult to identify confidently a strong area within the silk. It was therefore decided that the entire silk area should receive an adhered protective fabric overlay. It was essential that it should not alter the appearance of the silk noticeably nor interfere with the painted imagery and that the method of its application should involve minimal pressure. Dyed silk crepeline was selected to be the overlay and Klucel G was favoured as the adhesive, particularly as it could be dissolved in organic solvents. Klucel G was chosen with full knowledge of its potential limitations: its properties are discussed below.

Treatment Method
The preparation and application were as follows. The crepeline was laid onto polyester film, Melinex, and lightly misted with de-ionised water so that the grain could be aligned. Klucel G (5% in de-ionised water) was applied with a soft, small paint brush and allowed to dry.[3] For the purpose of accuracy, the Melinex was placed onto the picture and the crepeline was carefully cut to shape with a scalpel following the outline of the silk. The Melinex was then removed from the picture and the crepeline peeled off the

Melinex and laid into position on the silk picture.

Propanone (acetone) and ethanol were used to re-dissolve the adhesive and light pressure was applied to ensure that the crepeline remained in contact with the silk while the solvent evaporated. A small, stiff paint brush was used to apply the solvent. Propanone was used for those areas which were difficult to access and required more time to adhere as ethanol evaporated too quickly. Pieces cut from the selvedge of polyester crepeline, Stabiltex, were placed within the splits which exposed the linen backing. These were inserted prior to adhering the overlay of crepeline and were held to the linen with Klucel G. The conspicuous holes in the embroidered areas were infilled with dyed wool fibres also held in place with Klucel G.

The order of treatment of the second picture differed and will therefore be described briefly. This picture is believed to be after an 18th century print and shows a woman feeding chickens. It is of a fine cream silk gauze which was in extremely poor condition and had suffered considerable loss. Some of its structural damage can be attributed to the fact that the frame's glass was shattered and was subsequently held together with pressure sensitive tape.

Due to the fragility of the silk gauze, the protective overlay of silk crepeline was applied prior to the insertion of the patches used to 'disguise' missing areas. It was possible to slip the patches in underneath the silk gauze once it was stabilised as the embroidery was not worked around all sides and because the gauze had come away from the tacks holding it to the stretcher. The patches, which were of random-spun bonded polyester, Reemay, coloured with Helizarin printing pigments, were adhered to the underside of the crepeline. Lastly, the edges of the crepeline were folded around the stretcher and adhered to the back of the wood.

The crepeline was also taken to the reverse of the Hagar and Ishmael picture.

Hydroxypropyl Cellulose Adhesives

Klucel is the brand name given to a range of hydroxypropyl celluloses manufactured by Aqualon, formerly Hercules. Four grades of Klucel, namely L, G, H and M, were amongst the cellulose ethers evaluated by Feller and Wilt for use in conservation. Their findings, resulting from a three-year testing programme, were published in a monograph produced by the Getty Conservation Institute in 1990.[4] Their aim was to rank eight generic chemical classes of cellulose ethers in terms of their ageing behaviour. Their stability, or resistance to physical and chemical change, was judged by the following criteria: discolouration, loss of weight, loss of degree of polymerisation and the formation of peroxides. The ranking system took into account both the rate and degree of change.

It should be stressed that amongst their conclusions is the recommendation that further tests be carried out on the lower molecular weight Klucels, namely L and G. The higher molecular grades, H and M, were found to be unstable, but these are not commonly used in conservation.

Klucel L and G were found to have excellent photochemical stability to visible light and ultraviolet radiation and have little tendency to form peroxides. In this respect they are considered materials that will remain largely unchanged for at least 100 years under museum lighting conditions. However, thermal ageing tests indicate that they have the potential for discolouration and loss in the degree of their polymerisation resulting in reduced molecular weight and loss of viscosity. It was suggested therefore that Klucel L and G are placed in the intermediate class of stability and so are predicted to fail in 20-100 years.

It should be noted that the issue of discolouration may not be a problem for these treatments as Klucel was applied in a very thin film and so any colour change that does take place will scarcely be noticeable.

Conclusion

In summary, the treatment of the painted and embroidered pictures described was determined by the following factors. The pictures could not be stitched, pressure mounted or treated from the reverse. Stabilising the silk was essential but equally important was the need to retain the appearance of colour of the painted images. The silk could not withstand heat or pressure and water was to be avoided because of the presence of watercolour. Of the cellulose ethers which are soluble in polar organic solvents, Klucel G is one of the more stable types. The main concerns regarding the treatment undertaken are twofold: firstly, that the adhesive may fail, once more rendering the silk vulnerable; secondly, that the moisture regain of the new silk crepeline and hygroscopic cellulose ether will be greater than that of the degraded silks and so mechanical damage may occur during changes in ambient relative humidity.

Further investigation into the use of Klucel G for this type of conservation treatment is essential. The condition of the painted and embroidered pictures described above has not deteriorated according to the client, and the conservation is 'still invisible'. However, it has only been four years since the treatment was undertaken. Recent treatment of a painted and embroidered picture belonging to the Reference Collection of the Textile Conservation Centre was carried out using the method described with the aim of monitoring the stability of the materials used.[5]

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2 Cook, P and Leach, M, A report on the Adhesive Study Day, ***Conservation News*** 53 (1994), p 48.
3 Recent work (August 1994) by Janet Farnsworth, Scientific Assistant, Textile Conservation Centre, on preparing Klucel G coated silk crepeline, indicated that dissolving the adhesive in industrial methylated spirit rather than de-ionised water will result in a more uniform film.
4 Feller, R J and Wilt, M, ***Evaluation of Cellulose Ethers for Conservation***, Getty Conservation Institute (1990).
5 The treatment was undertaken by Janet Farnsworth, August 1994.

Materials and Suppliers

Klucel G hydroxypropyl cellulose
Conservation Resources UK Ltd
Unit 1, Pony Road
Horspath Industrial Estate
Cowley, Oxfordshire OX4 2RD, UK

Stabiltex polyester crepeline
Plastok Associates Ltd
79 Market Street
Wirral
Merseyside L41 6AN, UK

Melinex Polyester film based on polyethylene terephthalate
PSG Group
49-53 Glengall Road
Peckham
London SE15 6NF, UK

Reemay random spun bonded polyester
DHJ Industries (UK) Ltd
E N S Division
Etherow House
Woolley Bridge Road
Hollingworth, via Hyde
Cheshire SK14 8NS, UK

Helizarin pigments printing pigments
Hays Colour Limited
55-57 Glengall road
London SE15 6NQ, UK

Propanone acetone GPR grade
Ethanol
BDH Chemicals
Broom Road
Poole
Dorset, UK

Silk crepeline
Tassinari & Chatel
11 Place Croix-Paquet
69001 Lyon
France

POSTER: PASTE MAKING AT THE MUSEUM OF LONDON

PAPER CONSERVATION SECTION, The Museum of London, London Wall, London EC2Y 5HN, UK

1 Water is boiled in a double-boiler. *Zin shofu*, a Japanese precipitated wheat starch, is suspended in cold water. The percentage of starch used depends on the thickness of paste required (5-10% w/v).
2 The cold suspension is poured into boiling water.
3 The wheat starch is stirred and boiled for approximately one hour.
4 The paste is left covered to boil, unstirred, for approximately six hours. A crust will form on top of the paste which is discarded prior to decanting.
5 The storage jars are sterilised in a hot oven for half an hour.
6 The paste is decanted into the hot jars which are sealed quickly with a lid. A double layer of cling-film is applied over the lid as an extra seal.
7 The paste can used immediately but it will mellow with age and can be kept for many years. Once the seal is broken the paste should be refrigerated and used within two weeks.

Supplier
Zin shofu wheat starch
Lascaux Restauro
CH-8306 Brüttisellen
Zurich Strasse 42
Switzerland

POSTER: THE PREPARATION OF JAPANESE WHEAT STARCH ADHESIVE

ANDREW THOMPSON, Department of Conservation, The British Museum, London WC1B 3DG

The starch adhesive used in the Eastern Pictorial Art Section at the British Museum is prepared from gluten-free Japanese Wheat Starch. This is a highly processed wheat starch which combines both sizes of starch granules: type A, the larger granules, and also type B grains which are often discarded in Europe. The inclusion of the type B grains produces a smoother starch paste adhesive. The starch is soaked to remove any traces of gluten and to ensure that the starch granules are fully swollen prior to cooking. Although various starches differ, the proportions for cooking are approximately one part volume starch to three parts volume distilled water.

The mixture is cooked over a direct heat source and must be stirred vigorously throughout the cooking period of 40 to 60 minutes. During cooking the viscosity increases because of the crowding effect of the swollen granules but the vigorous stirring which subjects the paste to a high mechanical shear causes the paste to thin and increases its adhesive properties. The cooked paste is poured into a ceramic jar and allowed to cool before use. It weakens progressively with age and fresh paste is prepared every two to three days. Refrigeration is avoided as this weakens the paste.

To prepare it for use the adhesive must be sieved several times to remove any lumps. A traditional horsehair sieve bound with strips of cherry bark is used, but nylon sieves are equally effective. After sieving the paste is 'worked' in a paste bowl using a stiff Japanese brush called a *shigoke* (squeezing brush). This serves to further increase the adhesion of the paste. The desired consistency can then be achieved by slowly adding more water and working it into the paste a little at a time.

An 'aged' starch paste (*furu-nori*) is also produced by storing paste for around ten years. A large ceramic jar is filled with freshly cooked paste every winter, covered with a layer of water, and stored in a cool cellar. This water is changed annually, and the layer of surface mould removed. Prior to filling, the jar is 'seeded' with the 'top water' from previous years' aged paste so that the preferred moulds become established first.

POSTER:
THE TEMPORARY CONSERVATION / RESTORATION OF A PAINTED AND EMBROIDERED SILK PICTURE

WENDY TOULSON, Private Conservator, Bank Villa, Kingswood, Kington, Herefordshire, HR5 3HG, UK

Object
A 19th century embroidered and painted silk picture was brought in for temporary repair prior to exhibition. The picture is made from warp-faced tabby silk, backed with tabby undyed linen fabric and mounted on a strainer frame. It bears an image of a shepherd and his dog in a landscape; the face and hands of the shepherd and the sky are painted in a water-based paint, the remainder of the picture is embroidered in polychrome wool threads.

The picture is one of a pair - its counterpart depicts a shepherdess and sheep in a landscape. The pictures are housed in pole screens with rosewood veneer frames and brass mounts.

Condition
The picture was in a fair state. The wool embroidery was sound. There was a small hole in the painted silk sky, a larger hole in the shepherd's right hand and a substantial area of loss to the shepherd's face.

Brief
The owner wished to display the screens in a temporary exhibition of furniture; he was concerned that the damage to the shepherd picture was such that it would distract attention from the screen as a whole. He wished the loss to be made inconspicuous for the duration of the display.

Selection of Treatment
Initially it was hoped to slip patches of new dyed silk, with the missing features lightly sketched in, under the edges of the remaining original silk. However, the silk fabric proved to be so tightly held against the linen backing that it was difficult to slip a shaped patch between the two layers without risking damage to the original silk or distorting the patch itself.

The restoration of badly damaged painted images is controversial, even when preparatory sketches and comparative material are available. Painted and embroidered pictures of this type seem often to have been based on paintings and engravings, but the pattern for this particular pair has not yet been recognised.

In this instance, as the treatment was to be for temporary display only, it was decided to cover the damaged fragments of painted silk and the areas of loss with patches of new painted silk. This procedure would give the picture the appearance of completeness when viewed from a distance while preserving the original fragments underneath.

Treatment
The picture was removed from its glazed frame.

A piece of dyed new tabby weave silk fabric was taped out over a tracing of the damaged hand and face. A series of 'replica' hands and faces were sketched onto the silk with Elbetex acrylic fabric paints. The paints were heat set. The painted silk was pasted on the reverse with a 10% w/v solution of Klucel G in de-ionised water. When the silk was dry, the most acceptable hand and face were cut and positioned over the damaged portions of the picture. The Klucel G was re-activated with acetone applied to the obverse of each patch, which was held in place against the remains of the original silk and the linen backing until the solvent had evaporated.

A patch of dyed silk coated with Klucel G was slipped through the hole in the painted sky and was adhered in place on the linen backing by the application of acetone.

The picture was replaced in its frame.

Condition After Treatment
Viewed from a distance the picture looks complete. On closer inspection and on comparison with the companion picture it is clear that the face and hand are not original.

The fragments of the original painted silk are held in place behind the patches. After exhibition, the adhered patches can be removed by being swabbed with acetone and carefully peeled back.

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