Sodium Carboxymethylcellulose (SCMC) Re-evaluated for Paper, Book, Papyrus, and Parchment Conservation

&

A New Material for the Conservation of Papyrus

Cathleen A. Baker

Sodium Carboxymethylcellulose (SCMC) Re-evaluated for Paper, Book, Papyrus, and Parchment Conservation

Abstract

The cellulose ether, sodium carboxymethylcellulose (SCMC), has long been used in England as an all-purpose adhesive, consolidant, and sizing agent, while its conservation use in the United States has been limited. Compared to methylcellulose, it is a better adhesive, and in some conservation treatments, may be preferred to both methylcellulose and starch paste due to its unique properties. The recommended SCMC is Aqualon Cellulose Gum CMC 7H3SF PH—a pharmaceutical quality, high-viscosity-grade SCMC. Because of its long polymer chains, this particular SCMC is recommended as an adhesive and for delivering water as a “wet” poultice; it should not be used as a sizing agent or in any situation where the penetration of the cellulose ether is required. This SCMC is easy to make, store, and use by professional conservators in the treatment of paper and other related materials, e.g., papyrus and parchment. It is especially useful in situations where there are extensive repairs/reinforcement to be made and when bound-in book pages need to be treated, as well as for the relatively simple conservation of large, varnished, cloth-backed wall maps. Additionally, SCMC is particularly well-suited for use by non-conservators as an archival-quality adhesive.

Introduction

While a paper conservator working in England in the 1970s, I customarily used ICI’s Cellofas B3500—a technical grade, sodium carboxymethylcellulose (SCMC)—as an adhesive and sizing agent (I do not recommend the use of this particular SCMC). During my first few years teaching paper conservation in the Cooperstown Graduate Program, I tried to convince American paper conservators of the merits of SCMC but without success. The adhesive of choice in this country was starch paste, primarily wheat, which was rightly regarded as a proven, traditional material. Not wanting to “buck the system” by teaching non-traditional techniques and materials to students, I learned how to make and use wheat starch paste from the late Keiko Keyes. However, I remained convinced that SCMC and another cellulose ether—methylcellulose (MC)—had great potential for use in paper conservation. I decided to study these materials, and the results were presented at an early meeting of the AIC Book and Paper Group and the 1984 Paris meeting of the International Institute for Conservation, and published in subsequent articles (Baker 1982; Baker 1984). As far as I know, these activities had little influence on the use of SCMC in this country, while MC has gained popularity. However, while MC has many desirable attributes, e.g., great permanence and durability, it is not an effective adhesive in situations when the bond is stressed or when the surfaces to be adhered are smooth and compact.

In 1982, when I first presented information to American paper conservators about the use of SCMC as an adhesive, a few voiced their concerns about the sodium content; in pharmaceutical grades, this averages around 7.5%, compared to Methocel A 4M and 4C that have an average sodium content of 2.75%. Sodium is considered problematic because, as a component in an aqueous solution, it tends to swell cellulose fibers, which can cause some physical weakness to wet paper. However, the sodium in SCMC is strongly tied up within the polymer and should not impact the paper in a negative way. Additionally, when a high-viscosity grade is used, the long polymer chains inhibit penetration into the paper. As a discrete adhesive film, therefore, the sodium associated with SCMC and MC should not present problems to the stability of the support and repair materials, and indeed, Feller and Wilt (1990) found these to be stable materials.

Almost a quarter century has passed since those BPG and Paris papers, and for the last half of that time period, I have been involved in activities that did not center directly around conservation practice. However, in late 2005, I accepted a position as the flat paper conservator for the University of Michigan Library. When a conservation treatment called for the use of an adhesive, I reached for the wheat starch paste. In addition to paste alone, I also used a mixture of it and MC (Methocel A 4M), a.k.a. "The Mix," first developed for making a remoistenable backing paper (Baker 1990; Brückle 1996; Wagner 1996).

A few months into my new job, I was treating large maps, most with numerous tears and weak, tattered edges. What I needed for this kind of project was an adhesive that did not require pressing to dry flat and did not cause tide lines (some of the maps could not be washed). Neither dilute starch paste or The Mix were appropriate in this situation. A concentrated solution of a high-viscosity grade MC might have worked, but these artifacts are primarily research materials, as opposed to being part of a museum collection. Therefore, compared to museum artifacts, they are *handled* more regularly by both curatorial staff and researchers, and they are stored loose in folders in flat files, rather than in more protective window mats. Thus the repairs on these mended artifacts are subjected to more stress and require a stronger bond than can be provided by a comparable MC, and I chose to use a high-viscosity grade SCMC instead.

Sample treatments

Faced with repairing a very large (1.15 x 1.45 m), early eighteenth-century Japanese folded map, I thought that SCMC would be an ideal adhesive to handle this particular situation that involved reinforcing the entire perimeter (almost 17 feet) of the worm-eaten map (printed on a thin, adsorbent *kozo* paper) with Japanese tissue (fig. 1).

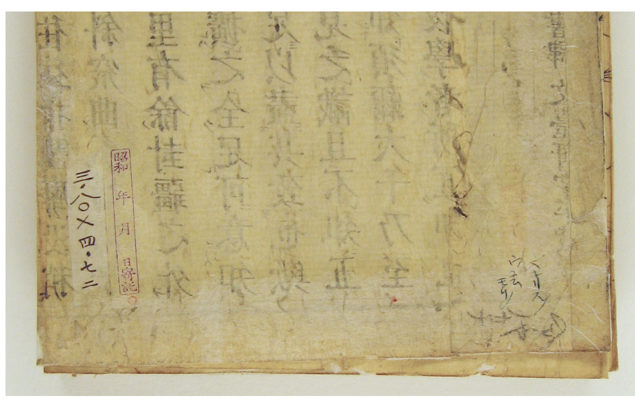

Fig. 1. Detail of edge reinforcement with Japanese tissue and SCMC. Sōshun, *Nansenbushū bankoku shōka no zu*, Keicho (Kyoto), 1710. Woodcut on *kozo* paper in black and red inks with *sumi* inscriptions. 1.15 x 1.45 m, Map Library, University of Michigan Library, G 3200 1710 .H6.

I found a pharmaceutical quality, high-viscosity grade SCMC that was made by Aqualon: Cellulose Gum CMC 7H3SF PH (this replaces the comparable Cellulose Gum CMC 7HSP that was available in the late 1980s). I made up different concentrations of this SCMC from 2.5% to 4% with conditioned, deionized water (pH 7.5). The 4% solution and tissue reinforcement dried without wrinkling, created no tide lines, and the repair was securely held in place. The procedure was: After water-cutting the edges of HM–1 *Tengucho* (Hiromi Paper International, Inc.), I laid a long, dry tissue strip roughly in place along the edge. Starting at the left, I lifted up the tissue and brushed the SCMC onto the map paper. Then I placed the tissue onto the adhesive, and with my finger, I gently "massaged" a little more adhesive through the tissue to the map paper below; I proceeded to the next 6-inch-long section, allowing the treated part to air dry. At first, the overhang of tissue beyond the edge of the map resulted in a slightly curled edge after drying. This curl could easily be pressed out locally, but I soon discovered that if the water-cut edge of the tissue was laid just inside the edge of the map, with no overhang, then the reinforced edge air-dried flat. The success of this repair and the efficiency with which it could be done spurred me to try this technique successfully on similarly damaged maps printed on Western paper.

Soon, Norm Harris and Jeff Gilboe in our book repair section were using 4% SCMC to solve some of their problems, and this same adhesive quickly replaced the not-always-reliable 2% Methocel A 4M previously used in the Special Collections Library to attach book plates. Leyla Lau-Lamb and Tom Hogarth, book conservators with whom I work, tried various concentrations of SCMC to repair pages in bound books, to reattach endpapers, and to reverse the concave curve in boards. (The latter is accomplished by brushing a very thin layer of 3% SCMC to the pastedown and air drying. The slight shrinkage of the adhesive is enough to draw the board flat. If the curve is great, several thin applications of SCMC, each coating air-dried in-between, may be necessary.) To everyone's surprise, a remoistenable repair paper made with 4% SCMC (see below) was successful in repairing tears in parchment.

Another application for this adhesive was in the treatment of nineteenth-century, varnished plat maps. These cloth-lined maps, which often hung for decades in classrooms and city halls, are typically dirty, torn, tide-lined, and detaching from their wooden rollers, while the paper is delaminating from the cloth. The varnish is discolored, and if it was exposed to water in the past, it has often bloomed to a cloudy film. The problems conserving these maps are myriad, time-consuming, and expensive, but if left untreated, these invaluable research materials are subject to the continuous loss of valuable information due to handling. Decades ago, I developed a technique of conserving these types of maps, which involved readhering the paper to the original cloth lining, with the added benefit of reforming the varnish into a clear, if still discolored, film. This technique is relatively simple, requiring only a large enough table to support the entire map, a few pieces of blotter or pressing felts, non-woven polyester sheets, and in some cases, weights for pressing. SCMC is the adhesive of choice because of its bonding properties, its "dry" quality, and its limited shrinkage upon drying.

First the map is dry cleaned—front and back—to the extent that its condition will safely allow. If pieces are detached, they can be applied locally to the map after treatment; if semi-detached, they should be adhered into place from the front with 4% SCMC. In preparation for the consolidation, thick blotters or pressing felts are laid on the table in a pattern large enough so that at least a 2-inch margin extends beyond the map. On top of this, one layer of Reemay or Hollytex, again with at least a 2-inch margin, is laid on the blotters or felt. The map is then placed facedown, and beginning at the top or bottom of the map, a line of 2.5% SCMC is applied along an edge. Using fingers, the adhesive is massaged in—like finger painting—so that it penetrates the cloth down to the paper. I work in 5-inch wide sections running from one side to the opposite one until that section is evenly impregnated, wiping off any excess adhesive. Then I move down to the next section, applying more adhesive as necessary, etc. It is best do not work too long in one area because there is the risk of over-wetting the front of the map. Once the entire map is treated, wipe off any excess and ensure that the edges are well impregnated and slightly stuck to the non-woven material underneath (fig. 2); this helps to keep the map flat during air-drying.

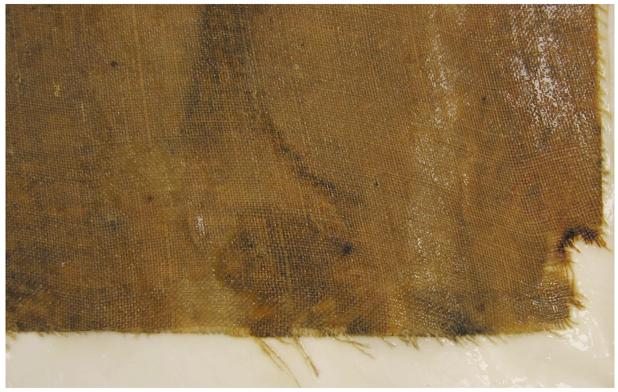

Fig. 2. Verso, detail of the frayed edges of a large, varnished map impregnated with SCMC. *Phelps & Ensign's travellers' guide, and map of the United States*, 1837, 1840. Intaglio on wove paper, hand-colored. 0.745 x 1.05 m, Map Library, University of Michigan Library, no catalogue number.

If the map is large, two people can work together, one on each side moving from the center out to the sides. Once the whole map is consolidated, check again for any excess adhesive and remove it. Allow the map to air dry completely. If there are splits through both the paper and the cloth, these can be reinforced from the verso with a Japanese paper during this treatment. Once dry, the map may curl slightly along the edges and along breaks in the paper, but these can be pressed out, either overall or locally, by slightly humidifying first and placing under light but even weight. (If the map is large, place weights evenly around the perimeter, rather than try to cover the entire area.)

A few years ago, Leyla and I began discussing the problem of producing an archival repair tissue for field papyrologists to replace the ubiquitous and potentially damaging self-adhesive tapes. After several experiments, we developed a water-remoistenable backing paper/repair tape (see figs. 7–18), based on the technique I had previously developed using The Mix. To test the efficacy of this paper/tape, we gave samples of the brown-dyed Japanese *kozo* tissue coated with 4% Cellulose Gum CMC 7H3SF PH, along with instructions for use, to the attendees of a papyrology conference held at the University of Michigan in late summer 2007 and asked for feedback; results can be found in the note by Leyla that follows this article.

Background on Cellulose Ethers

Cellulose ethers are synthetic materials obtained by chemically modifying pure cellulose with a variety of compounds. Such ethers have vastly different purity grades, viscosities, solubilities, etc. These differing characteristics make them useful as adhesives, binders, surfactants, coatings, sizing agents, consolidants, fixatives, gel media, poultices, solvent-delivery substrates ("wet" poultices), surface cleansers, etc. If made with pure solvents and if stock solutions are not contaminated during use, pharmaceutical-grade cellulose ether solutions have a long shelf life and need no refrigeration. Other grades, including technical, are not recommended because their solutions often lose viscosity upon standing and have been observed to turn green.

Many of the characteristics of a cellulose ether, e.g., whether soluble in organic solvent or water, are dependent on the type of ether group and the degree of substitution (DS) of the group onto the –OH on the cellulose unit. Because it is difficult for the DS to be exactly planned or determined, manufacturers usually give a range of DS values for cellulose ethers. Since the DS values can vary considerably from batch to batch, the same cellulose ethers purchased in different batches may have slightly different properties, such as viscosity.

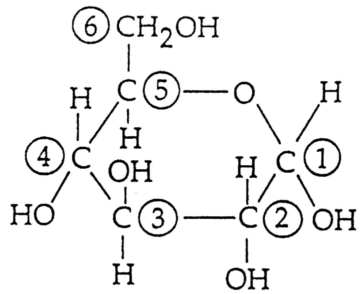

Fig. 3. Cellulose unit.

Methylcellulose, for example, is made by first treating native cellulose with a strong alkali such as sodium hydroxide, NaOH. (**R** = rest of cellulose ring)

Step 1.	**R–OH**	+	**NaOH**	=	**R–ONa**	+	**H_2O**
	cellulose unit		sodium hydroxide		alkali cellulose		water

The alkali cellulose becomes methylcellulose when it is treated with methyl chloride, CH_3Cl.

Step 2.	**R–ONa**	+	**CH_3Cl**	=	**R–OCH_3**	+	**NaCl**
	alkali cellulose		methyl chloride		methylcellulose		sodium chloride

Sodium carboxymethylcellulose, $C_6H_9OCH_2COONa$, is derived from alkali cellulose treated with sodium monochloroacetate.

Generally, the higher the degree of polymerization (DP) number, the longer the polymer chains, and the higher the viscosity grade of cellulose ethers. The viscosities of cellulose ether solutions are controlled by altering the DP of the native cellulose *before* etherification. Also, it is generally true that the higher the DP of a polymer, the more stable it is to aging. Experiments have indicated (Baker, 1984) that some artificially aged cellulose ethers are very stable compared to a similarly aged wheat starch paste.

Purchasing a cellulose ether without knowing the exact type of cellulose ether, purity, viscosity (cPs), brand name, and date of manufacture might lead to disappointing and inexplicable results. Suppliers should publish, or at least make available upon request, this information. With regard to purity and archival properties, pharmaceutical or premium grade is highly recommended, food grade is acceptable, but neither industrial nor technical grade can be recommended. If you can determine the manufacturer, go to the Internet or write/call for technical information, the MSDS, instructions for making solutions, and by all means, request samples of the various types and viscosities available. Experiment with these by varying the concentrations to see how different and useful these materials can be.

Feller and Wilt (1990) published an important study entitled *Evaluation of Cellulose Ethers for Conservation*. Using the results from that study as well as my own findings, the table below (fig. 4) lists popular cellulose ethers in preferred order; rankings are based on stability after artificial aging.

Type (Brand Name)	**Manufacturer**	**Concentrations & Uses**
methylcellulose (Methocel A 4M Premium)	Dow Chemical	2.5%: additive to stronger adhesives, such as starch pastes and PVA 1–4%: surface cleanser, poultice, solvent-delivery substrate, consolidant
methylcellulose (Methocel A 4C Premium)	Dow Chemical	2–3%: sizing/resizing agent, surface cleanser, solvent-delivery substrate
sodium carboxymethylcellulose (Cellulose Gum CMC 7H3SF PH)	Hercules/ Aqualon	2–4%: adhesive, surface cleanser, poultice, solvent-delivery substrate, consolidant
hydroxypropylcellulose (Klucel G)	Hercules	consolidant for friable leather: air-brush: 0.5% in ethanol; brush applications: 1% in ethanol
methylcellulose (Culminal)	Hercules/ Aqualon	technical grade: generally, not recommended for conservation
sodium carboxymethylcellulose (Cellofas B 3500)	Imperial Chemical Industries (ICI)	technical grade: generally, not recommended for conservation

Fig. 4. Rankings of popular cellulose ethers.

The popular leather consolidant Klucel G (hydroxypropylcellulose (HPC); Hercules Inc.) is soluble in water, ethanol, and methanol. However, its use should be restricted to situations when a more stable cellulose ether or other adhesive cannot be used, such as a consolidant for deteriorated leather, “red-rot.” Feller and Wilt found Klucel G to be not as stable as other cellulose ethers, no doubt because Klucel G is a low-medium viscosity-grade cellulose ether (ca. 270 cPs in a 2% water solution, measured at room temperature).

A warning: While one person might praise a cellulose ether for a certain application, another may condemn it. Chances are they are not using the same viscosity grade of a particular cellulose ether, or perhaps, two entirely different cellulose ethers. For example, one supplier is selling sodium carboxymethylcellulose but also refers to it as methylcellulose, as if these names are interchangeable. Because people are often confused by this, I like to use the analogy: cellulose ethers are fruit; MCs are apples, SCMCs are oranges, HPCs are grapes, etc.)

Methylcellulose vs. Sodium Carboxymethylcellulose

Although both of these are cellulose ethers and often considered the same, the recommended MC and SCMC at the same concentration have dissimilar properties (fig. 5).

Methylcellulose	**Sodium carboxymethylcellulose**
non-ionic	ionic
poor bonding strength	good bonding strength

powder/film not soluble in water >80°C	powder/film soluble in cold or hot water
high-surface activity: "wet"	low-surface activity: "dry"
pH ~7.5	pH ~7.5

Figure 5. Properties of methylcellulose and sodium carboxymethylcellulose.

Taking these properties into account, the user can tailor one or a mixture of the two to do the job required. In addition to these properties, one must consider the different viscosity grades associated with each kind of cellulose ether, and the effect of the concentration of solutions. In my 1982 paper, I stated that MC and SCMC were not strong adhesives, but that opinion was based on their use at 2.5% concentration. At higher concentrations, such as 4% for SCMC and 5% for MC, the adhesive strengths will be improved. However, due to its inherent ionic property, SCMC will be a stronger adhesive at the same concentration than MC, although neither will ever match a strong starch paste or PVA. It should be noted that solutions of the high-viscosity-grade Methocel A 4M or Cellulose Gum CMC 7H3SF PH cannot be made up in concentrations much exceeding 5% using ordinary blenders because the solutions are simply too thick.

Viscosity can be measured in a number of ways and is often expressed in the unit centipoise (cP). For example, Methocel A and Cellulose Gum CMC are sold in various viscosity grades:

	Average Centipoises (cPs)
Methocel A 4M	4000
Methocel A 15C	1500
Methocel A 4C	400
Methocel A 15	15
Cellulose Gum CMC 7H3SF PH	3800
Cellulose Gum CMC 7MF PH	600
Cellulose Gum CMC 7LF PH	40

Figure 6. Viscosities of 2% solutions of various Methocel A and Cellulose Gum CMC at 20°C.

Because viscosity is linked to the degree of polymerization (DP), both Methocel A 4M and Cellulose Gum CMC 7H3SF PH form long polymer chains in solution that become increasingly entangled in relatively high concentrations (2.5–4%). When applied to paper as an adhesive (or a binder for paste papers), the polymer is so entangled that it cannot penetrate far into the paper. However, the water is readily absorbed into the paper/board/cloth. This latter fact gives the impression that the entire solution is being absorbed. When the paper is dry, however, most of the polymer film has formed on the surface to which it was applied. (For Methocel A, especially, this film often produces a glossy or sparkling effect on the paper surface. This can be reduced by wetting a finger tip with saliva and quickly "daubing" the shiny areas until they are matte.)

If a high-viscosity-grade cellulose ether is used for sizing or resizing, then theoretically the concentration must be low enough so that this entanglement and film formation is reduced and penetration is increased. The problem is that, since this concentration might be 1% or less, there would be so little polymer in the paper that the properties of the cellulose ether to be imparted are negligible. For this reason, the medium- or low-medium-viscosity-grade cellulose ethers—especially the recommended Methocel A 4C—are far more appropriate sizing agents because they are composed of much shorter chains (Baker 1992). When used in much higher concentrations, such as 2–3%, the polymer chains do not entangle, and penetration occurs. For sizing purposes, SCMC is not recommended over Methocel A because the latter has superior properties for this application. Note: Although low-viscosity-grade cellulose ethers, e.g., Methocel A 15, would penetrate paper very well, we can predict that, because the polymer chains are so short, its degradation would occur at a much faster rate than has been observed in the medium- or low-medium-viscosity-grade cellulose ethers.

As an adhesive in the same concentration, SCMC has a distinct advantage over MC in that it has better adhesive properties, even when the bond is stressed. However, it will not adhere to smooth, non-porous surfaces, such as glass, and in high humidity situations, it (and most other cellulose ethers) may swell and block onto an adjacent surface. SCMC dries to a film with minimal shrinkage, remains flexible, and reverses with small amounts of water. It is easy to make, requiring only "kitchen" tools, although an accurate scale is helpful. If made with deionized or distilled, conditioned water and stored in a sterilized, air-tight container, and the stock solution is not contaminated, it will keep until used up completely. It is non-toxic, unappealing to pests, and if kept "clean," the solution will not lose its viscosity, grow mold, or turn green. Because of these properties, SCMC as an adhesive can be used with confidence by the professional paper, book, photographic, parchment/vellum, and papyrus conservator, by minimally trained library and archival collections personnel, as well as framers, artists, scrapbook keepers, etc., and makers of paste-paper (a purpose for which it is very well suited).

Conclusion

I can highly recommend Aqualon Cellulose Gum CMC 7H3SF PH as a conservation-quality adhesive for use by paper, book, photographic, parchment/vellum, and papyrus conservators. It can also be safely recommended to the non-conservator as a reliable, archival adhesive that is easy to make and use, can be stored at room temperature without spoilage, and is non-toxic. The dry film is resistant to pests and fungal attack.

Steps to Prepare a Remoistenable Sheet for Backing/Lining or as a Repair Tissue

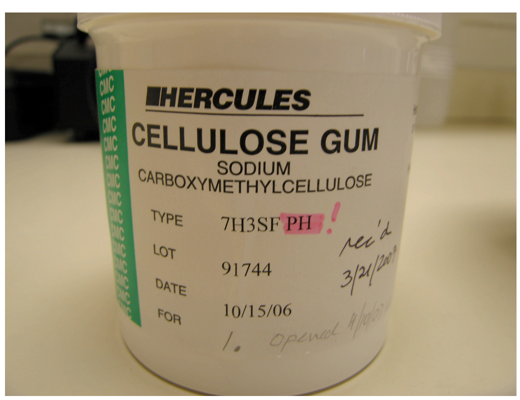

Fig. 7. The recommended SCMC is manufactured by the Hercules' company, Aqualon, and is sold under the brand name, Aqualon Cellulose Gum CMC 7H3SF PH. Notes: 7 = 0.7 degree of

substitution (DS); H = high viscosity; 3 = no information available; S = yields smooth solutions; F = food; PH = pharmaceutical grade.

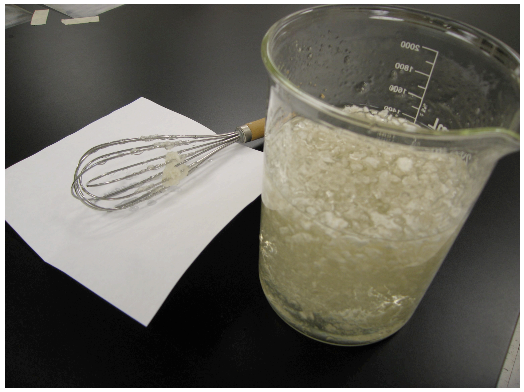

Fig. 8. This is a 4% solution just after the powder has been added; it is too thick to be made in an ordinary blender. Once the powder is weighed out, it is gradually added to room-temperature water (deionized or distilled, conditioned with saturated calcium hydroxide to pH 7.5), using a whisk. If made this way, lumps quickly form, but these will completely solubilize in a few hours, if stirred occasionally. Hint: a “potato masher” helps speed up the process. Once solubilized and transferred to an clean, air-tight container, the product information should be transferred to a label along with the date the solution was made. This adhesive can be stored indefinitely without refrigeration; it is very resistant to mold and unappealing to pests.

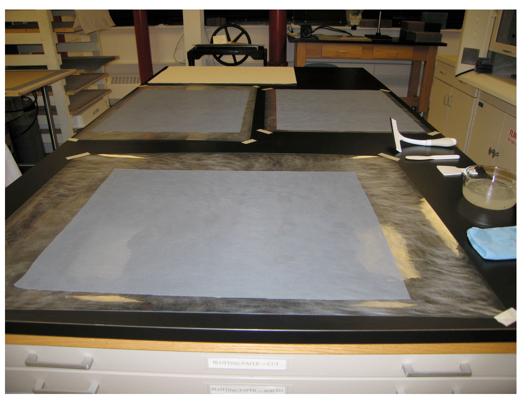

Fig. 9. This is the set-up for making several sheets of remoistenable backing/repair tape at a time. Roughen the surface of a sheet of 5-mil polyester film (Mylar or Melinex) with fine sandpaper; wipe clean. (Do not roughen the Mylar too much or you will have difficulty removing the paper after drying.) The Mylar should be at least 2 inches larger than the sheet of Japanese paper chosen. Secure the corners of the Mylar to the table with masking tape. Cut a piece of gray fiberglass window screening at least 2 inches larger than the paper. If a thinner layer of adhesive is desired, use a finer screen, such as Pecap (Wagner 1996). Also set out a large piece of pressing felt or thick blotter, several sheets of polyester non-woven material (Reemay or Hollytex), blotting paper, and a water sprayer. Tools: squeegee, scrapper, shallow bowl containing adhesive, wet towel, and large, stiff brush, e.g., *nadebake* (not pictured).

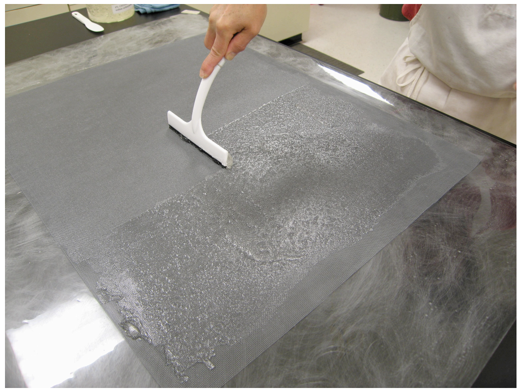

Fig. 10. Position the screen on the Mylar and apply a row of adhesive along the top edge of it. Using the squeegee, drag the adhesive down to the bottom. The right-hand side of the screen, as in the illustration, shows the smoothed, even adhesive layers, while the left-hand side shows the adhesive layer before squeegeeing. Note the angle of the squeegee and the force required to push the adhesive into the screen, which evens out the layer. As necessary, scrape excess adhesive off the squeegee into the bowl. Make sure to fill any gaps in the screen with adhesive. Using one continuous motion, pull the screen off. If washed thoroughly and handled carefully, all materials that come in contact with the adhesive can be reused many times. Hint: Before you start, place a sign on the Japanese paper that reads “TAKE THE SCREEN OFF” to remind you to do so before you accidentally lay the paper on the screen!

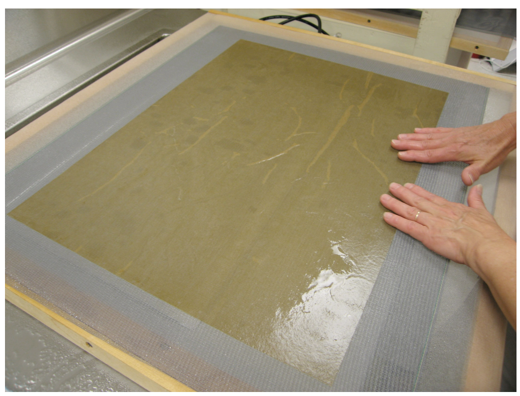

Fig. 11. Some Japanese papers will wrinkle if laid dry onto the adhesive layer. Medium thick papers can be sprayed or humidified and applied to the adhesive layer, but thin ones need to be thoroughly wetted and expanded first. Shannon Zachary suggested pre-wetting thin paper (the one we chose for papyrus conservation: Colored Kozo, CK-3, sold by Hiromi Paper International) on a piece of the same kind of screen, blotting it, and then, supported by the screen, placing the fragile paper onto the adhesive. Above, Leyla is carefully pulling out the wrinkles in the thin paper during pre-wetting; excess water allows this to occur without tearing the paper.

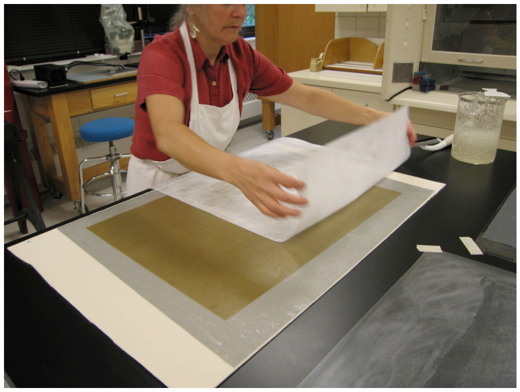

Fig. 12. To remove the excess water from the Japanese paper, lay it, supported by the screen, on the pressing felt or thick blotter. Place *two* sheets of Reemay onto the paper. Then place a clean blotter on top and use hand-pressure to adsorb the water.

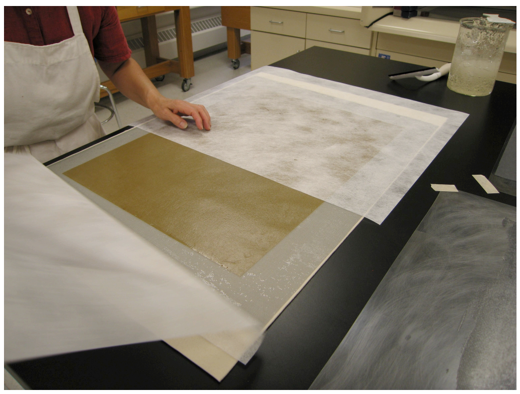

Fig. 13. After blotting, remove the upper Reemay sheet from the center toward the side. This technique prevents the edges of the paper from lifting off the screen, dropping down, and wrinkling; repeat for the second piece.

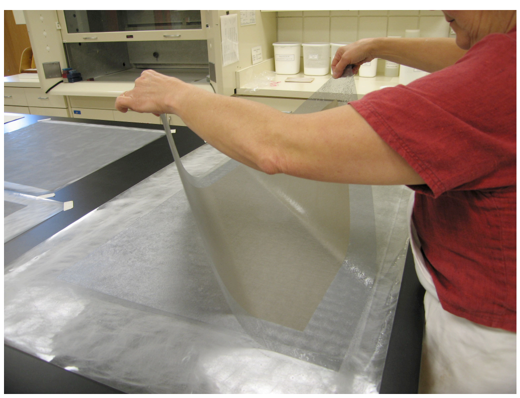

Fig. 14. Invert the screen and carry the paper (facedown) to the adhesive layer and using the motion illustrated above, lay the paper down.

Fig. 15. Leaving the screen in place, place one large or two smaller sheets of Reemay on top, as above. Using the *nadebake*, lightly brush the paper onto the adhesive. Strokes should start along the center and work out beyond the edges of the Reemay to reduce wrinkling and to secure the edges of the paper onto the adhesive.

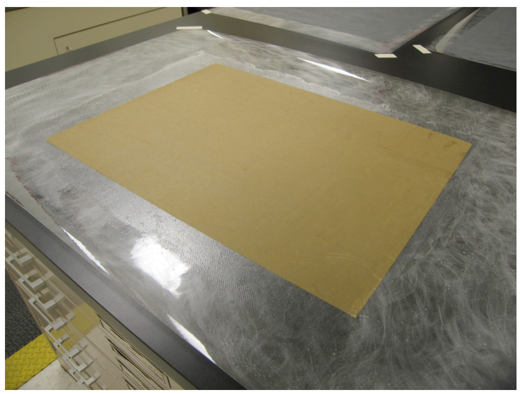

Fig. 16. Remove the Reemay and the screen, and leave the paper to air dry completely on the Mylar.

Fig. 17. When the paper is dry, turn the whole over and peel away the Mylar, keeping the paper flat. In a dry environment, the paper has a tendency to curl, and it can be stored rolled or flat (see the note following this article by Leyla Lau-Lamb).

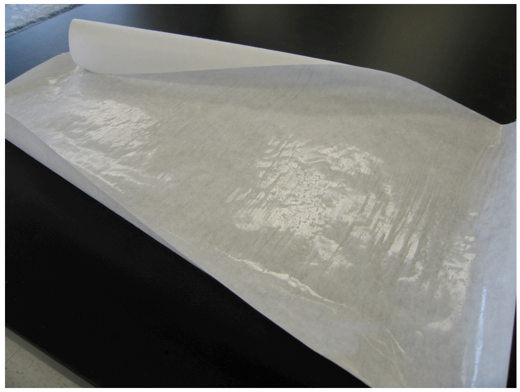

Fig. 18. To use the remoistenable backing/lining, lay the paper adhesive-side up and lightly spray with water or humidify until you can lift up a corner of the paper by pressing a fingertip on the adhesive. If too wet, allow the sheet to dry and start over. Apply the moistened sheet to the reverse of the artifact as you would normally. Drying options: 1) air dry between drying screens, 2) adhere around the edges of the backing/lining to a *karibari*-style screen/board, or 3) put between Reemay and blotters in a press with light but even pressure. One advantage to this technique is that the backing can be placed on artifacts that are dry or only slightly humidified. The resulting bond, while not great, is evenly distributed over the original's surface, and unless the artifact undergoes appreciable stress, this bond should be sufficient to support the artifact, keep tears together, reduce creases and folds, etc. To reverse this backing, lightly spray the reverse with water and peel the Japanese paper away; sometimes this backing/lining can be peeled away dry. If strips made from this sheet are used for tear repairs, the adhesive is reactivated by brushing either side lightly with water. Once damp, place the strip along the tear or bridge it, and apply finger pressure for a few seconds; the "tape" dries almost instantly. While this backing sheet/tape can be torn, the customary fibrous, "water-cut" edge is not possible.

Materials and Suppliers

Aqualon Cellulose Gum CMC 7H3SF PH
TALAS (item #: TAD081001)
    330 Morgan Avenue
    Brooklyn, NY 11211
    http://talasonline.com
University Products (item code: 544–3126)
    517 Main Street
    P.O. Box 101
    Holyoke, MA 01041–0101
    413–532–3372
    http://www.archivalsuppliers.com/
BookMakers (A-SCMC)
    http://www.BookMakersCatalog.com
    301–345–7979

Japanese papers
for papyri:
Colored Kozo (CK)

100% *kozo*
color: CK-3 (tan)
size: 25 x 38 inches
weight: 11.5g/m^2
Hiromi Paper International
2525 Michigan Avenue
Bergamot Station Art Center, Unit G-9
Santa Monica, CA 90404
washi@hiromipaper.com

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Cathleen A. Baker, PhD
Senior Conservator
The University of Michigan Library
Ann Arbor, Michigan
cabake@umich.edu

Leyla Lau-Lamb

A New Material for the Conservation of Papyrus

Parts of this article were originally distributed to papyrologists at the XXV Congress of Papyrology, July 31–August 3, 2007, Ann Arbor, Michigan.

Abstract
For many years papyrologists and conservators of papyri have used different kinds of tape to align papyrus fragments. Some of these tapes have been very damaging to the papyrus or to the writing on it. In this short paper I relate my experience using a remoistenable adhesive—a 4% solution of a pharmaceutical grade, high-viscosity-grade sodium carboxymethylcellulose (SCMC), Aqualon Cellulose Gum CMC 7H3SF PH and Japanese paper (Colored Kozo, CK-3, Hiromi Paper International). This experimental remoistenable paper was given out to attendees at the XXV Congress of Papyrology, July 31–August 3, 2007 held in Ann Arbor, Michigan. Initial indications from a number of international papyrologists is that repair strips made from this remoistenable paper are proving useful, not only at excavations, but also in papyrological institutions.

Remoistenable Tissue for Repairing and Aligning Papyrus Fragments

Over many years as a papyrus conservator, I have seen numerous repairs and alignments done with all kinds of tape. In the early years, papyrologists used postage stamps, or white and brown gummed-paper tape. These were opaque tapes with water-remoistenable adhesives. Because no one could see through these, they were often applied in areas where there was no writing, mostly on the back of the papyrus. Generally, they can be removed safely by dampening the tape with a small amount of water using a brush; this removal rarely destroys fibers or ink.

In the 1950s a variety of self-adhesive tapes came into use for mending, and they consist of a clear or “frosted” cellulose-acetate carrier and an acrylic polymer adhesive. This kind of tape is also called pressure-sensitive because light pressure causes it to stick readily to any surface, including papyrus fibers. From papyrologists I have heard comments like: “Leyla, it was magical and sent from heaven because you can see through it.”

Unfortunately, pressure-sensitive tape presents a major problem for papyrologists and papyrus conservators. Time and experience have shown that pressure-sensitive tapes on papyri are disfiguring, damaging, and difficult—sometimes impossible—to remove without seriously damaging the papyrus or the writing on it. The adhesive is not water-soluble, it discolors, and over time it oozes and then dries out, leaving insoluble stains and adhesive residues in the papyrus fibers. Additionally, the tape no longer holds fragments in their initial alignment.

Relatively new “archival” tapes on the market are made with a thin paper carrier and an acrylic adhesive. For a short period of time—maybe a few months—these tapes can be removed with heat or a light application of an organic solvent. But once the acrylic adhesive has set and aged, organic solvents in increasingly heavier applications must be used to remove it, if it can be done at all.

During visits to several different collections and excavation sites to inspect papyri, I have been asked to help because a self-adhesive tape had been used and the original alignment had proven to be incorrect. In some cases I was successful in removing the tape, but in others I had to leave it in place. In this situation, I was asked to cut through the tape to separate the incorrect alignment so that the papyrologist could correct it.

In the past I experimented with different materials and also did research to try to find a commercial transparent, archival, and reversible tape, albeit unsuccessfully. My intention was to find a substitute for the pressure-sensitive tapes that are still being used by many papyrologists. Ideally mending strips need to be sound, non-damaging, and easy to remove. They also need to be convenient to carry to remote locations for use at excavation sites, and especially they must require a minimum of effort to use in order to compete with pressure-sensitive tape.

A few years ago our senior paper conservator, Dr. Cathleen Baker, introduced me to sodium carboxymethylcellulose (SCMC), an adhesive she has successfully used in paper conservation. I started working in book conservation with 2% and 4% solutions of the SCMC she recommends, Aqualon Cellulose Gum CMC 7H3SF PH. As I got to know more of the specifics, and the pros and cons of this adhesive I became interested in using it in the conservation of papyri. Together Cathy and I designed a remoistenable repair paper made with a Japanese handmade paper carrier and a 4% solution of the recommended SCMC. The materials, suppliers, and instructions for the production of this paper can be found in Cathy's article elsewhere in this *Annual*.

I distributed test samples (fig. 1) of this paper to 250 papyrologists in July 2007 at the XXV Congress of Papyrology. I asked papyrologists to try the tissue at their home institutions and in the field, and I have heard back from a number of them. Initial indications from practicing papyrologists is that repair strips made from this remoistenable paper are proving very useful.

Just Cut, Moisten, and Apply

From a larger prepared sheet, one can tear or cut small pieces or strips, and apply just a very small amount of moisture on the either side to reactivate the adhesive, using light finger pressure to hold in place for a few seconds. If very small strips are needed, a pair of tweezers are useful to hold the strip while moistening and positioning. It is not an entirely transparent material, but it is translucent. To remove the tape, if necessary, requires just a light application of moisture. The tape is stable over time, dries almost instantly, does not discolor, remains reversible in water, and is non-toxic. This tape is also resistant to pest and fungal attack, and has been successfully used in hot and dry climates.

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Leyla Lau-Lamb
Senior Conservator
The University of Michigan Library
Ann Arbor, Michigan
laulamb@umich.edu

Fig. 1. Trial samples of remoistenable mending tissue for papyrus.
These mending strips were made over the winter in very dry conditions, which caused the paper to curl. This turned out to be an advantage: I flattened the roll and vertically cut narrow strips ready to use. Left: the remoistenable Japanese paper rolled up into a tube and flattened; right: cut strips measuring 1–3 mm wide (leaving the top of the tube uncut makes the strips easier to handle and store).