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The Bishop Museum Tapa Collection Conservation and Research into Special Problems

Roger G. Rose,[1] Carol Turchan,[2] Natalie Firnhaber,[3] and Linnea O. Brown[4]

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1. Department of Anthropology, Bishop Museum, P.O. Box 19000-A, Honolulu, Hawai'i 96817-0916, USA.
2. Chicago Historical Society, Clark Street at North Avenue, Chicago, Illinois 60614, USA.
3. Anthropology Conservation Laboratory, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560, USA.
4. Department of Anthropology, Bishop Museum, P.O. Box 19000-A, Honolulu, Hawai'i 96817-0916, USA. Deceased.

ABSTRACT

Bishop Museum's tapa (barkcloth) project was made possible by National Science Foundation support in three intermittent phases from October 1978 to December 1985. Through research conducted by conservators affiliated with the Pacific Regional Conservation Center (PRCC), advances were made in understanding the nature of oiled and *māmaki* tapa and in investigating alternative methods for their preservation. New adhesives and repair tissues were found that meet generally accepted criteria for conservation. Satisfactory methods of deacidifying *māmaki* tapa were developed. Lining was shown to be successful in consolidating fragile specimens, but no satisfactory method was found to restore flexibility to brittle oiled specimens without altering their inherent characteristics. While good results were achieved in applying these various conservation techniques to oiled and *māmaki* tapa on a small, experimental scale, the logistics of treating large, multiple-sheet Hawaiian specimens present a new set of problems. This research revealed new materials and techniques that can be applied to conservation of tapa in the Bishop Museum and elsewhere.

INTRODUCTION

Barkcloth from the Pacific has been familiar to the Western world ever since Captain James Cook collected samples during his three voyages of exploration in the late 1760s and 1770s. Like subsequent visitors, Cook was astonished by the variety and utility of this paperlike fabric commonly called tapa (*kapa* in Hawaiian), which was beaten, usually by women, from the inner bark of the paper mulberry (*Broussonetia papyrifera*) and selected other plants. Throughout the Pacific as well as other areas of the tropics, tapa was used for clothing and bedding and countless other practical purposes; it was also a symbol of wealth and prestige and thus important in many kinds of ceremonial exchange. Infrequently made or used today, except in restricted localities, barkcloth collected over the last two centuries embodies a vast storehouse of knowledge about the indigenous cultures of the Pacific—art and technology, aesthetics and behavior, intra-Pacific relationships, and much more.

Bishop Museum's barkcloth collection consists of some 2,200 examples from the Hawaiian Islands and nearly 1,000 more from the rest of the Pacific and elsewhere. A systematic repository of international significance, the Hawaiian portion of the collection developed from a nucleus of family heirlooms amassed by Island royalty and deposited in Bishop Museum beginning with the Museum's founding in 1889. Supplemented over the years by purchases, gifts, a few exchanges, and some field collecting, the collection is exceptionally rich in 19th-century items such as bedding or sleeping tapas (*kapa moe*), skirts (*pā'ū*), loincloths (*malo*), and capes (*kīhei*). The collection also includes representative early samples collected by Cook (e.g., Shaw 1787) and other explorers. Transition-period specimens collected by American missionaries after 1820 and numerous cave fragments and samples spanning the immediate pre- and postcontact eras add further depth, as does the associated collection of tools used in the manufacture of tapa. The other Pacific collections are valued for their areal and temporal coverage, incorporating 19th- and 20th-century as well as contemporary specimens from island groups often unrepresented in other repositories.

The barkcloth collection was closed to research and exhibition in November 1973 when it became apparent that continued access to the tapas, then stored under antiquated conditions, would cause irreparable harm to specimens of such scientific and historic value.

In late 1978, a three-phase tapa conservation project supported by the U.S. National Science Foundation (NSF), was initiated at Bishop Museum. During Phase I (October 1978 through March 1980) and Phase II (April 1981 through September 1982) the Museum's barkcloth collection was consolidated into renovated, environmentally controlled, systematic storage. As a result, the bulk of the collection was returned to active use for exhibition and consultation by the local community and international scholars. Phase III (July 1983 through December 1985) of the project was a twofold approach of practical conservation and experimental research. Efforts focused on (1) application of stabilization and remedial repair techniques to badly deteriorated tapa specimens; and (2) research into specific conservation problems facing the most seriously deteriorated components of the Hawaiian collection, oiled tapa and *māmaki* (*Pipturus albidus*) fiber tapa.

CONSOLIDATION OF THE TAPA COLLECTION

Using procedures developed with the Pacific Regional Conservation Center (PRCC), the more than 3,000 tapas in the collection were transferred to new cabinets of special design (Fig. 1). As part of the process all specimens were humidified, unfolded, and treated to ease creases and wrinkles. Specimens were then assessed for condition. Catalog records were reviewed and updated and color transparencies taken of each tapa for public use and curatorial reference.

Tapa Storage

Through the years, the bulk of the Hawaiian collection had become compressed into 18 vintage metal cabinets wherein specimens were stacked up to 14 in (35 cm) deep on wooden shelves only 33 in (84 cm) by 21 in (53 cm). Most tapas had been folded multiple times to make them fit and many were badly creased, typically along 20 or more ingrained fold lines. Few could be retrieved without snagging on metal shelf runners or disturbing adjacent specimens, straining brittle fibers, and aggravating old creases and tears. The Polynesian and Melanesian tapas were stored on open wooden shelving in a room with limited work space on another floor of the building.

Devising alternative storage in the space available presented a considerable challenge, but a design based on curatorial experience and need finally evolved. Folding of tapa eventually causes creasing and uneven stretching as well as breakdown of fibers, soiling, and excessive wear along folded edges. Rolling was not a viable alternative because (1) many pieces in the collection are too fragile; (2) it would add stress to the seams and sheets of multiple-layer coverlets and wrap-around skirts, both common in the Hawaiian collection; (3) it would increase the potential for flaking of pigments from delicate or heavily painted specimens; and (4) accessibility would be restricted, as experience with a rolled mat collection elsewhere in the Museum had demonstrated. Since it was anticipated that the collection would be consulted by researchers and used for exhibition, it was essential to provide safe and easy access while avoiding physical damage such as could be caused by repeated unrolling and rerolling. Hanging or draping over rods, another storage method, would have required more floor space than was available, in addition to subjecting aging and delicate fibers to uneven and continual stresses. Flat storage, with no folding and equal weight distribution, would have been ideal but impractical, since trays up to 15 ft^2 (4.6 m^2) would be required to accommodate the largest pieces in the collection.

A compromise solution based on flat storage with minimal folding and stacking was adopted. In 1976 the Museum tested a prototype storage cabinet custom engineered by the Steel Fixture Manufacturing Company of Topeka, Kansas. Based on an enlarged version of their Model GL-C textile case, the prototype is a dust-tight, steel unit with locking double doors, measuring 81 in (206 cm) wide, 44⅞ in (114 cm) deep, and 36⅞ in (194 cm) high (external dimensions). Stackable two-high, each cabinet holds 15 metal trays 74½ in (189 cm) wide by 42 in (107 cm) deep and 1⅞ in (5 cm) high, or 10 trays 2¾ in (7 cm) high, or a combination of both. The largest design feasible without solving costly engi-

Fig. 1. Linnea Brown (left center, with white gloves) escorts tours through the renovated tapa storage at a formal reopening of the collection on Bishop Museum Festival Day, 20 April 1980. Cabinet doors at left were temporarily removed to accommodate display of Hawaiian *kapa* in partially opened drawers.

neering problems, the cabinet met requirements for long-term, safe storage of the tapa collection and provided both easy access and minimal folding and stacking. With assistance from the NSF, 19 additional cabinets were installed in January 1979 during Phase I of the project in an environmentally controlled, physically secure room 61 ft (19.6 m) long by 12 ft (3.7 m) wide. Six more units were installed with NSF support during Phase II of the project in July 1981.

Humidification

A procedure for transferring tapa from old storage to the new cabinets was developed in consultation with PRCC staff at Bishop Museum during Phase I of the project. Because of

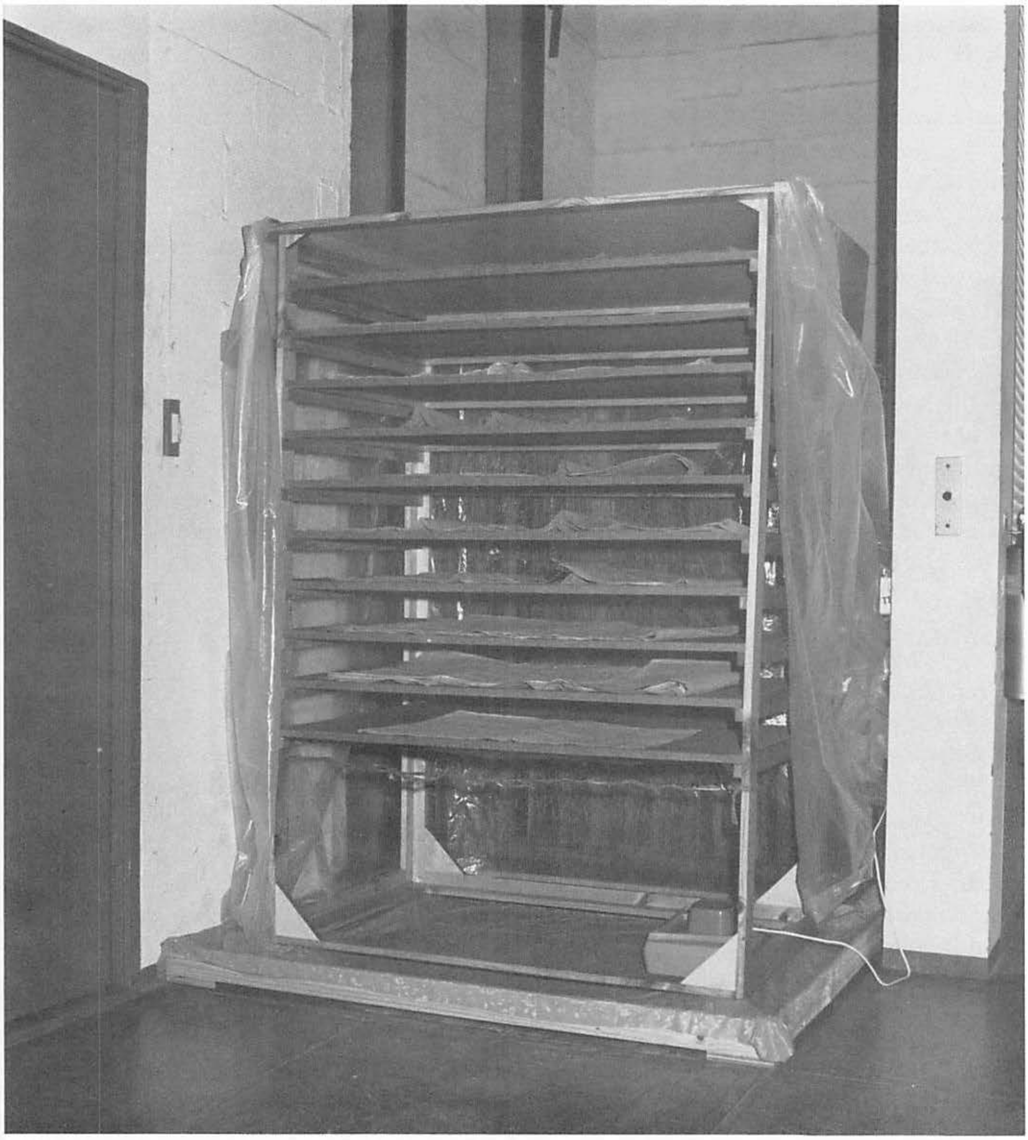


Fig. 2. Humidification chamber with plastic sheeting opened to show sliding screen shelves. Vaporizer (lower right) circulates distilled water vapor, softening aged and brittle tapa so it can be safely unfolded and creases removed.

age and brittleness, it was first necessary to humidify each tapa to relax old creases before it could be safely unfolded and prepared for the transfer. For this purpose an open-frame cabinet 50 in (127 cm) wide by 31 in (79 cm) deep by 72 in (183 cm) high was constructed from wolmanized ¾ in (2 cm) pine and fitted with runners spaced 5 in (13 cm) apart to accommodate 10 sliding fiberglass shelves, each measuring 48 in (122 cm) by 30 in (76 cm). This humidification chamber (Fig. 2) was coated with a polyurethane varnish to prevent water absorption and warping, then loosely encased with polyethylene sheeting taped to the 2½ in (6 cm) top overhang, leaving a front access panel. The humidifier, a DeVilbliss Model 250 vaporizer purchased from a local drugstore for about $12 in 1978, was placed on the chamber floor, which was covered with more plastic sheeting to retain any condensation. Another piece of sheeting attached to the bottom of the lowest shelf prevented the jet of humidified air from directly contacting tapa, while the flexible walls of the chamber allowed circulation to the uppermost shelves. Distilled water was used in the humidifier, which with weekly cleaning and drying provided trouble-free service during one year of nearly constant operation. The unit was cleaned every three or four months with an ordinary household bleach solution to inhibit mold growth. The chamber was installed near the tapa workroom, outside climate-controlled collection areas.

An assembly line procedure was devised to treat tapa sheets safely and efficiently, beginning with the Hawaiian collection and following the catalog and storage sequence. Each tapa was examined when removed from the old cabinets and, if generally sound, partly unfolded (one or two folds) to allow inspection of the inner surfaces. The partly opened sheet was then fitted onto a sliding tray in the humidification chamber. When the chamber was filled, it was sealed. Depending upon size and bulk, 10 to 15 specimens usually filled the chamber and they were humidified together. Eight to 12 hours with the vaporizer running all or most of the time usually sufficed to humidify and relax the tapas. When the tapas began to relax during the process they could be opened further and returned to the chamber for an additional period until the moisture had time to fully permeate the entire fabric. No negative effects were observed if humidified specimens were left in the sealed chamber with the vaporizer off for two or three days.

Unfolding and Flattening

Once humidified, each tapa was carefully unfolded on a large work table covered with acid-free blotter paper. If further relaxation was required, distilled water was sprayed over the opened sheet with a fine mist sprayer (Fig. 3). Care was taken to aim the nozzle well above, not directly onto, the tapa. Spot tests were made beforehand to determine the stability of any dyes present. Of some 2,200 Hawaiian pieces treated, fewer than a dozen were so color fugitive that spray had to be avoided; about 10–15% were slightly fugitive and had to be misted sparingly. Each tapa reacted slightly differently to misting, some requiring more moisture, others (particularly the thinner, finer-textured examples) very little to promote pliability and to relax old crease lines. Some sheets absorbed water more readily than others, so it was important to use the mister sparingly and evenly to prevent damp spots that could cause localized stretching. Care was required to avoid dampening the edges, since stretching would be more likely to occur.

After overall misting with distilled water, most fold lines could be eliminated simply by pulling very carefully and gently near the borders of the tapa. This worked best if two persons stood opposite one another and pulled with a slight upward, billowing motion. Small pieces of plate glass, 3 in (8 cm) to 6 in (15 cm) long by 4 in (10 cm) to 5 in (13 cm) wide, were placed over stubborn fold lines and weighted, particularly where old creases intersected. Pouches for weighting were constructed from cotton duck material and filled with lead shot. These were made in two sizes, each useful in different situations: 2¾ in (7 cm) by 4 in (10 cm) and 1¾ in (14.5 cm) by 3 in (8 cm), weighing approximately 26 oz (750 g) and 9 oz (250 g), respectively.

Tapa that had been badly stretched along old fold lines could never be flattened adequately. Moreover, small wrinkles tended to reappear in the stretched areas, especially if the tapa was not weighted. While stubborn creases flattened under weighted glass, minor folds and tears, especially along the edges, could be relaxed (using more distilled water if necessary) and gently eased back into alignment by careful manipulation with the fingers. Unless severely deteriorated, most sheets could be relaxed and wrinkles smoothed in 30 minutes to an hour. After flattening, each sheet was completely covered with acid-free blotter paper to absorb moisture and to promote drying.

Fig. 3. Linnea Brown sprays fine mist of distilled water onto sheet of Hawaiian tapa to help remove old wrinkles; glass plates weight stubborn creases. Fold lines caused by storage in old cabinets at left would eventually cleave if left unattended (BPBM D. 1517).

Although some quite fragile tapas required extremely gentle handling, most could be safely processed in this careful but routine way. Ten to 20 single sheets could be treated by two or three persons in a normal day's operation. The pace and method of treatment were complicated considerably by fragile or deteriorated specimens, however, and to a lesser extent by Hawaiian multiple-sheet coverlets (*kapa moe*) or skirts (*pā'ū*). *Kapa moe,* about the size of ordinary bed sheets, consist usually of a decorated cover sheet (*kilohana*) and four or five or more plain inner sheets (*iho*) stitched together along one edge. *Pā'ū,* normally about 1 m wide and 3–8 m long, can also be made from one to ten layers stitched together along one long border. In these specimens, comprising some 30% of the Hawaiian collection, the sheets had to be gently peeled open, one at a time, and treated individually, taking care not to strain the stitched seam. Often the seam itself required special attention to eliminate numerous small folds and creases.

After several treated specimens had accumulated on the work table, the entire stack was weighted with heavy, industrial-quality paper-making felts. These provided even weight to press out minor bulges and prevent old wrinkles from re-forming during drying. This flattening process did not alter the natural texture of the tapa. Drying was fairly rapid, requiring no more than 8 to 12 hours for a stack of a dozen or more bed-size sheets. Air conditioning equipment removed excess atmospheric moisture from the workroom, with no abnormal fluctuations in ambient temperature and relative humidity noted.

Photography and Documentation

Drying completed, usually overnight, the felts and blotter papers were removed to reveal flattened, wrinkle-free tapa ready to be photographed and documented. A 35-mm Canon AE-1 camera equipped with a 25-mm wide-angle lens, remote-control shutter release, and automatic film advancement was ceiling-mounted about 9 ft (2.7 m) above the work table with two 3,200-Kelvin tungsten lamps. At least two Kodachrome color transparencies were taken of each specimen after treatment, one for curatorial reference and one for public use in the Museum's photograph collection. The new transparencies and any pre-existing black-and-white negatives of the same specimen were cross-referenced with catalog numbers for easy retrieval and all photographic materials were mounted in protective archival sleeves. After being photographed, each tapa was described, measured, and checked against the original catalog data (which were updated as necessary), then placed in the new storage cabinets.

About 30 specimens proved to be too far deteriorated to respond to the humidification and unfolding procedures. For one reason or another they could not be housed with the bulk of the collection so were set aside for further consideration. Some *māmaki* (*Pipturus albidus*) tapas were too fragile to be unfolded without immediate conservation; other specimens were three-dimensional: cave bundles, shaped turbans, tightly compressed loincloths, and other items. These specimens were photographed, measured, and placed in acid-free tissue in archival storage boxes. Conservators outlined recommendations for their ongoing care and possible future treatment.

GENERAL TAPA CONSERVATION PROCEDURES

During Phase III of the project, stabilization and remedial conservation was undertaken on selected tapas by trained volunteers working under the direct supervision of PRCC conservators and a project coordinator (Appendix A). Conservation treatments were completed on 50 specimens during a 12-month period with origins as follows: Hawai'i, 36; Samoa, 10; Niue, 1; Futuna, 1; Solomon Islands, 1; and Japan, 1. Specimens ranged in size from small samples a few square feet (1 m^2) in total area to full-sized sheets some 10 ft (3 m) per side. Most treatments were labor intensive and averaged about 46 hours per specimen, although one Hawaiian *kapa* required 198 painstaking hours to repair and stabilize. Some 2,200 hours contributed by volunteer labor were expended to stabilize these 50 specimens, which does not include the tissue toning, photography, record keeping, supervision, and other supportive tasks.

During Phases I and II of the tapa project, all specimens in the collection were assigned conservation priority ratings on the basis of condition. Specimens to receive treatment were selected primarily from among those rated as most urgently in need of treatment. Hawaiian material took precedence, after which uniqueness as well as aesthetic and historical qualities were considered. Hawaiian tapa was given priority because it constitutes by far the largest portion of the collection and because the art of tapa-making in Hawai'i has been lost for nearly a century—a tragic circumstance making it even more imperative to preserve what still exists. Fortunately, contemporary artisans are attempting to relearn the techniques that created the outstanding traditional examples that have been preserved. Hawaiian *kapa* is characterized by its rich diversity of color, pattern, texture, beatermark, and weight.

Here are the procedures for general tapa conservation found to be useful during Phase III of the tapa project at Bishop Museum.

Repair of Tears and Breaks

Repair of tapa is consistently carried out using a variety of thin, long-fibered Japanese tissues such as *usomino, sekishu, tengujo,* or *kizukishi.* Available from conservation supply

Fig. 4. Losses are being filled and splits mended and tamped down with a Japanese brush prior to lining the specimen fully with Japanese tissue and rice starch paste. Left to right: Marcia Morse, volunteer, and Carol Turchan, conservator (BPBM 6880).

houses, Japanese tissues have been used successfully in paper conservation and the inherent qualities of the material make it equally suitable for the repair of barkcloth. Because of their thinness and exceptionally long-fibered structure, Japanese tissues adhere well without adding appreciable thickness or drastically changing the character of tapa. Many Japanese tissues are made from paper mulberry, and the tissue is traditionally a pure, unaltered material. Paper mulberry is also the major source of fiber for Hawaiian and most Polynesian barkcloth, so its use seems appropriate.

Mends are fixed to tapa with thin, rice starch paste (Appendix B). Used with Japanese tissues, rice starch paste has good tack, is flexible, does not impart a stiffness to the mend, and is easily reversed or removed by dampening with water. Japanese tissue is "water-torn" along dampened lines into narrow, ¼ in (0.5 cm) strips, then torn again into lengths about ½ in (1.2 cm) to ⅝ in (1.5 cm). Such small sections of repair tissue are desirable to maintain the tapa's flexibility, particularly that of very thin Hawaiian specimens. Repair tissues are liberally coated with diluted rice starch paste over blotter paper to absorb excess moisture, transferred to the area to be mended and tamped down with a soft Japanese stencil brush (Fig. 4). This action brings the tissue into full contact with the tapa fibers. The proper consistency of the paste, neither too watery nor too thick, is important to bond the repair tissue well yet not stiffen or distort the cloth. Mends are weighted between blotter paper to dry them flat, with polyester web placed in direct contact with the mend to prevent the blotter from adhering.

Japanese tissues can also be toned to resemble the base or ground color of a tapa so that mends on the verso (back) are not so visible and distracting to the eye. Toning tissue prior to application can eliminate the need to hand-paint repaired areas later. Water-soluble acrylic pigments have been used successfully to impart either a thin wash of color or a

Fig. 5. Found in a small cave bundle (cf. Fig. 4, 6), this Hawaiian tapa was unfolded, patterns realigned, and the tiny fragments held in place with temporary "butterfly" mends applied to the decorated side.

deeper, more saturated tone to tissue. Watercolors are not desirable because of the risk of the color bleeding onto surrounding barkcloth fibers. Appendix C describes the process of toning tissue for repair.

When there are very long or uneven tears, or numerous tears in an area, the design must be realigned before repairs are begun. Realignment of a design area is done from the front and edges are held by small, temporary ("butterfly") mends attached perpendicular to the tears on the face of the tapa (Fig. 5, 6). These remain in position until the piece can be turned and fully repaired from the back. An untoned tissue should be used for the temporary attachments so they may be easily seen; they can be removed following repair by lightly

Fig. 6. Decorated side of the same (cf. Fig. 4, 5) badly deteriorated Hawaiian cave specimen after lining; compensated areas can be inpainted as necessary for exhibition.

moistening and lifting with a spatula. Splits that sometimes occur along thin areas of the beatermark in finely textured Hawaiian examples are similarly repaired, as are fragments broken away from larger specimens. Samples cut in the past for tapa reference books can also be returned to the original specimens if desired, using the same mending technique.

In the course of repair it is often necessary to flatten a specific area more fully to eradicate an ingrained crease or fold or straighten a crushed edge. This can be done by lightly dampening a small piece of blotter paper, applying it to the area, and weighting it until the area is sufficiently relaxed to allow smoothing. A fresh blotter can then be applied to dry the area flat. Because of the uneven surfaces of most tapa, flexible weights as described above are helpful during localized flattening and repairs.

Filling Losses

Holes or other areas missing material (losses) are filled from the verso with tissue that has been toned in advance to a color approximating that of the tapa under repair. The fill is formed by laying tissue over the loss and tracing with a wet brush around the outline of the loss plus an overlap of less than ⅛ in (0.3 cm). The dampened tissue is then quickly torn while wet and the edge fibers "feathered" or extended. For most small losses the entire fill is pasted up and applied over the loss. The tamping brush is used to bond the fill to the tapa fibers around edges of the loss and to push the fill toward the front of the tapa. It is important that a release material always be placed beneath the repair to prevent adhesion to the table covering. It may be desirable to apply a second layer of tissue to the loss if a thin, toned tissue is used and the tapa tends to be heavier in weight. This makes the fill more visually satisfying. If many large losses must be filled in a heavy tapa, it is worthwhile to tone a heavier weight tissue having an acceptable texture.

Care must be exercised in filling losses—first determining that they are not natural branch holes in the raw material, ethnographic marks such as sewing holes, or other indications of the specimen's function or manufacture. Large missing sections of more than a foot or two square should not be filled with full or partial sheets of Japanese tissue. This would create an unsightly, inharmonious addition and normally not contribute to the stability of the specimen. If an uneven edge or protruding fragment is in danger of breaking away, discretion must be used in securing it. Often the best solution is as much a matter of aesthetic judgment as it is conservation.

When barkcloth fibers are all aligned in the same direction in a single layer, lateral separations may sometimes occur. Such separations are found in some 18th-century Hawaiian paper mulberry tapas that are rather soft and thick (Fig. 7, 8), and have been observed in other kinds of tapa as well. Repair of such damage requires realignment of fibers from the front and application of paste very sparingly along the edges of the separation. A few strategically placed temporary mends should be applied to secure the area until the mend can be reinforced from the verso with tissue. The repair tissue is applied in short sections joined end-to-end. Temporary mends on the face will help in locating the rejoined area on the verso, since the weakened areas disappear from view when drawn together.

The application of acidic dyes to some tapas has ultimately resulted in their embrittlement and damage. The dyes seem to penetrate through the fibers, whether on heavy, multi-layered pieces such as those from Samoa or thin Hawaiian specimens. Affected areas are cracked and generally have suffered some loss. All such areas are potential losses and must be reinforced at the site of damage with applications of tissue and starch paste. While specimens have individual requirements, in general reinforcement involves the linking of fragile, dyed areas to stronger, undecorated portions of the surrounding tapa with long-fibered tissue mends. One Hawaiian specimen decorated with acidic clusters of stamped designs was consolidated using numerous small pieces of Japanese tissue that did not overlap

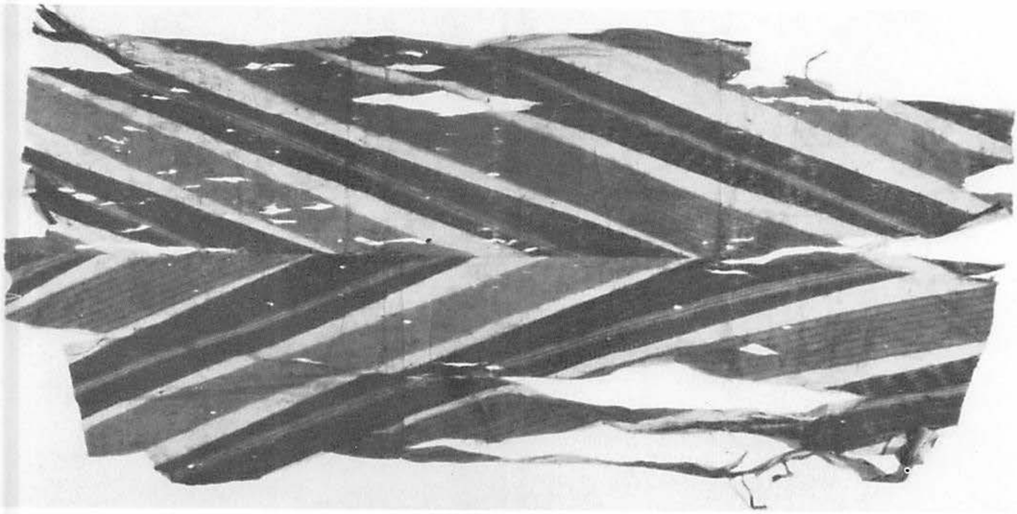


Fig. 7. Old Hawaiian *kapa* collected by American missionary Dr. Seth Andrews ca. 1837–1848. Fibers have separated laterally to the extent that major conservation is required to prevent continued deterioration. Note sewn seams and distinctive patterning, both characteristic of late 18th-century Hawaiian barkcloth (BPBM D. 2206).

except for the edges of "feathered" tissue fibers. In this way flexibility of the tapa was maintained even though the consolidated areas were distributed extensively throughout the specimen.

Lining

When damage or deterioration is extensive, a full lining of Japanese tissue applied to the verso of a tapa will provide necessary additional reinforcement (Fig. 9, 10). Lining is a

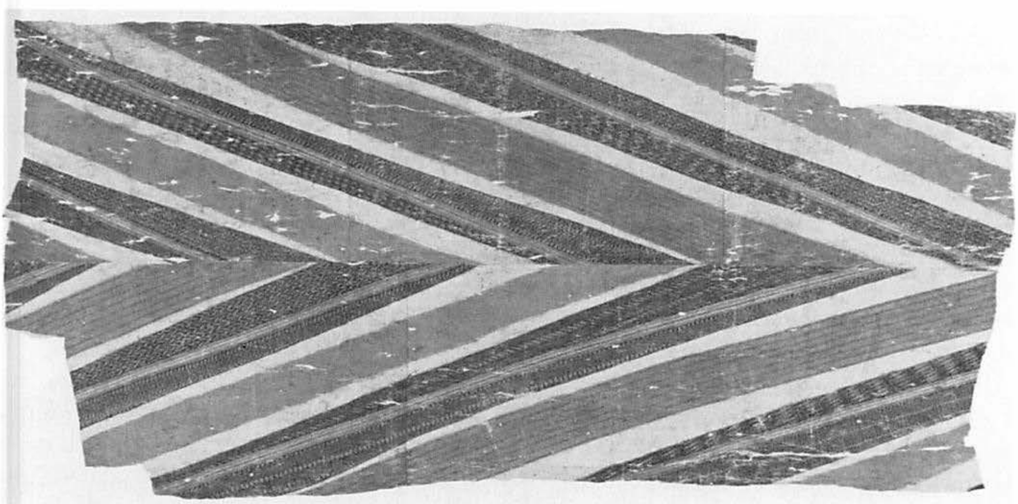


Fig. 8. Laterally separated fibers (cf. Fig. 7) were realigned from the front and secured by application of rice starch paste along edges; a few strategically placed temporary "butterfly" mends allowed tapa to be turned over, then reinforced from the verso with thin strips of Japanese tissue.

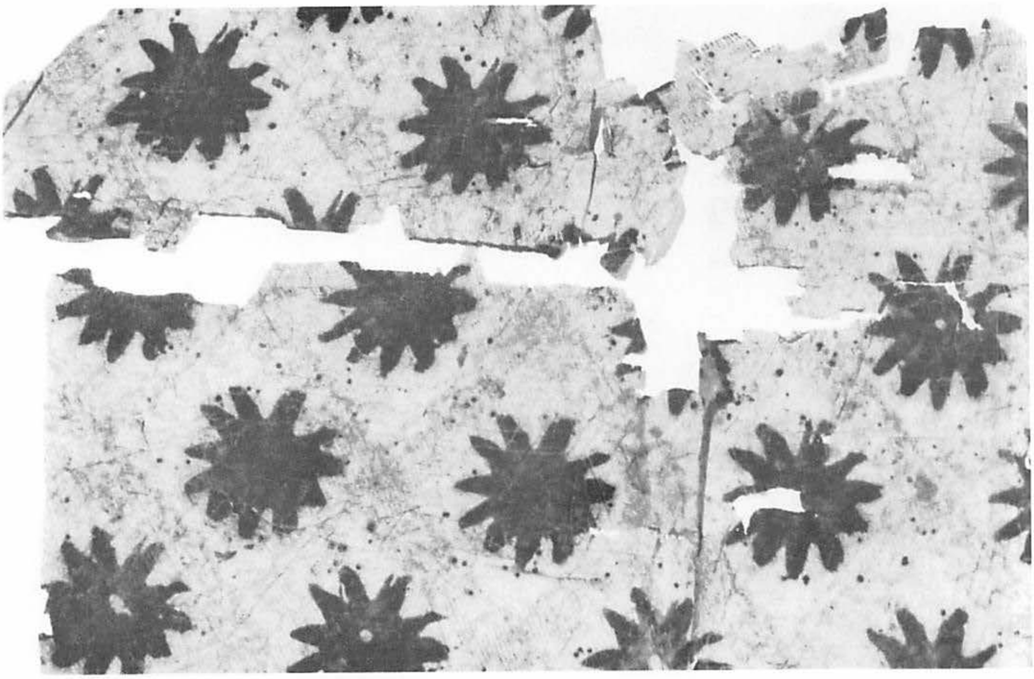


Fig. 9. This fragment of Hawaiian paper mulberry tapa has a fine beatermark and is very brittle; severe breakage along the beatermarks and edges of the fabric can be stabilized by lining (N/N-30).

complicated procedure, however, and should not be attempted except as a last resort and only when fully justified by extensive deterioration of the specimen.

Lining requires thoughtful planning and preparation. All other repairs must be made and losses filled prior to lining. If the tapa is very large it may not be possible to complete the process in a single day. Because the work can be physically demanding, lining of larger tapas should be undertaken only with the aid of an assistant. The nature of the lining process demands that one be able to anticipate how the tapa will respond to the introduction of moisture, the application of lining materials, and subsequent drying. All of these factors must be controlled.

A very thin, long-fibered Japanese tissue is preferable for lining. *Tengujo* has proven ideal for lining tapa of any weight; because of its softness and flexibility, there is less imposition on the character of the cloth. Though delicate, when properly handled the wet strength of *tengujo* is sufficient to withstand the process. The tissue should be toned. Even a slight tone will make it possible to see through the lining to the back of the tapa. This is important since there are sometimes old markings or evidence of manufacture or use that should not be hidden. A toned tissue is also less disturbing to the eye and more complementary to the object.

Rice starch paste is the preferred adhesive for lining because it can be very dilute and still adhere well. The consistency of the paste is important; it will contribute significantly to increased stiffness of the lined tapa if too thick and may not adhere at all if too thin. The nature of the barkcloth itself will determine the necessary consistency, tone, and weight of lining materials. Preliminary tests with proposed materials may be done on a sample to anticipate responses and results.

The tapa is placed face down on a surface covered with blotter paper and a release material (so that the lining will not adhere to the table covering). The portion of the tapa to be

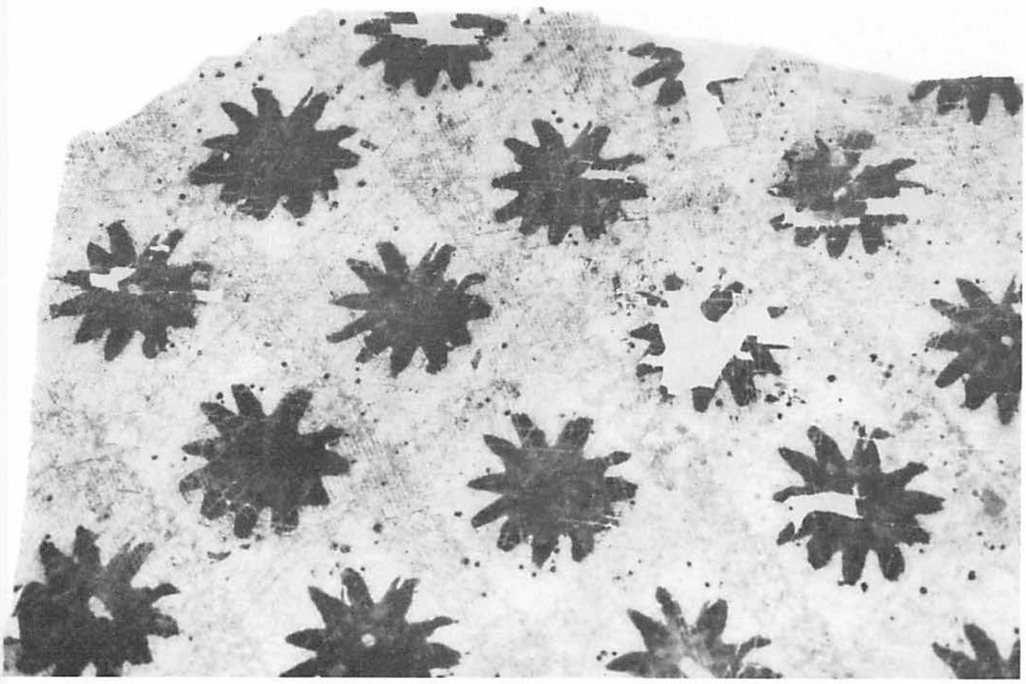


Fig. 10. Wrinkles and creases have been removed (cf. Fig. 9) and the specimen repaired and fully lined on the verso with toned Japanese tissue.

lined is first relaxed by light misting with distilled water. If this is not done, the barkcloth fibers will quickly absorb moisture from the pasted tissue when it is applied: stresses will be placed on both barkcloth and tissue, resulting in restrained expansion, and the thin lining tissue could tear under the strain. Considerable expansion will occur when moisture is absorbed into the cloth.

Because of its limited wet strength, *tengujo* tissue is pasted on mylar first and then transferred to the tapa. The size of the tissue sections should be determined by the ease with which they can be handled or controlled and the size of the tapa. Once the wet tissue is lying on the surface of the tapa and the mylar has been carefully pulled away, it must be quickly "pounded" to bond it fully to the barkcloth fibers. One of the most effective tools for this procedure, possessing the essential combination of firmness and flexibility, is a wire-bound bookbinder's glue brush at least 2 in (5 cm) in diameter. Since the thin *tengujo* dries rapidly and barkcloth surfaces are irregular, any area of tissue not forced down into contact with the tapa with such a brush will not adhere. The lining in that area will bubble and the tapa will not be supported.

The lined section should be allowed to air dry for a short time, while it resumes its natural plane. The next section can be lined as the first is stabilizing. Polyester web, blotter paper, and weighted glass may be applied when the area is sufficiently flat. Blotters should be changed as necessary to facilitate drying. Sections of tissue used in the lining should overlap only along water-torn edges to minimize stiffness in those areas.

Lining should not be considered unless the condition of the tapa fully requires it. Despite thoughtful application and use of the most complementary of materials, inevitable changes occur after lining. Some of the natural irregularity and flexibility of the tapa is lost. Much more is gained, nevertheless, by consolidating a potentially doomed specimen when lining is the only alternative.

Finishing

Once a tapa is lined or otherwise repaired, the borders must be finished. Natural edges of barkcloth are not like paper objects—straight, angled, and sharp—so a method to create a border in keeping with the soft, uneven edge of tapa was devised. A small, wet watercolor brush is run along the very edge of the cloth and any excess Japanese tissue resulting from repairs or lining is pulled away with forceps. The remaining fibers are then lightly brushed with very dilute paste and rolled with thumb and forefinger against the edge of the tapa. It is important to remove as much excess fiber at the edge as possible and to keep the paste very thin; otherwise a hard, inflexible edge will result.

Finally, a method of attaching catalog numbers to tapa specimens was devised, eliminating the need to apply ink directly to the barkcloth. The number is written with permanent India ink onto a small strip of water-torn Japanese tissue, which is then pasted up just as with a repair and attached to a corner of the tapa. The strip should be tamped down so that adhesion is assured.

Special Problems with Samoan Tapa

Samoan tapa (*siapo*) consists normally of multiple sections and layers of paper mulberry barkcloth adhesively joined together during manufacture with starch from the arrowroot (*Tacca leontopetaloides*) tuber. Like tapa from Tonga and certain other Western Polynesian localities, more emphasis is placed on applied design than on textural perfection in the production of *siapo*. The fabric is coarse, and decorated tapas are thicker and less flexible than Hawaiian tapa. Because of the paste and surface decoration, Samoan barkcloth tends to be stiff and resistant to folding or rolling.

Dye made from sap of the *'o'a* (*Bishofia javanica*) tree and perhaps other plants is sometimes applied over the surface of a *siapo*. The acidic dyes applied to many decorated Samoan tapas can saturate the fibers and cause them to become prone to cracking with age, in time resulting in severe breakage and loss of design areas. Some Samoan *siapo* are "glazed" or "varnished" with dyes over their entire surface, in which case lining is the only means of consolidating the cloth. When repairs are made it is necessary to apply paste to the edges of the breaks as well as to the repair tissue, which is applied to the verso, and to tamp the mend well to the brittle, compacted fibers.

Both old and new Samoan barkcloth, decorated and undecorated, have been used successfully to mend Samoan tapa. In some repair situations it may prove more suitable than Japanese tissues. Repairs using barkcloth can add stiffness when completely pasted onto the specimen, however, and the mends do not adhere well with thin rice starch paste.

Samoan and other similarly manufactured tapas are prone to damage from insects attracted to the arrowroot starch residue. An acceptable means of repairing large areas lost through insect attack has not yet been established. Lining was attempted but the natural thickness of the barkcloth seems to require heavier lining tissues, primarily to compensate for the large areas of loss. A heavy lining throughout, on the other hand, results in a stiff, intractable tapa.

HAWAIIAN OILED AND *MĀMAKI* TAPA

Concurrent with the above remedial and stabilization procedures, research was conducted into special problems posed by oiled tapa and tapa beaten from *māmaki* fibers. These two varieties of Hawaiian tapa are very different from each other in material composition and surface decoration, yet similar in their degree of deterioration and need for individualized conservation treatment. Such specimens constitute a large proportion of the Hawaiian collection rated as in urgent need of stabilization or repair. Since previous experimentation had determined that standard paper conservation techniques applicable to the bulk of the collection could not be used readily and successfully to treat these problematical specimens, other methods were devised and tested.

Oiled and *māmaki* tapa were singled out for research because most show characteristically severe forms of deterioration that potentially could result in complete loss of numerous specimens. There is little specific information in the literature documenting special treatments these tapas may have undergone in the process of manufacture or decoration that would account for their present fragile condition. In our research we examined the properties of each of these varieties of tapa and tried to understand how and why they were made as they were. We also tested alternative conservation materials and methods of application to oiled and *māmaki* tapa.

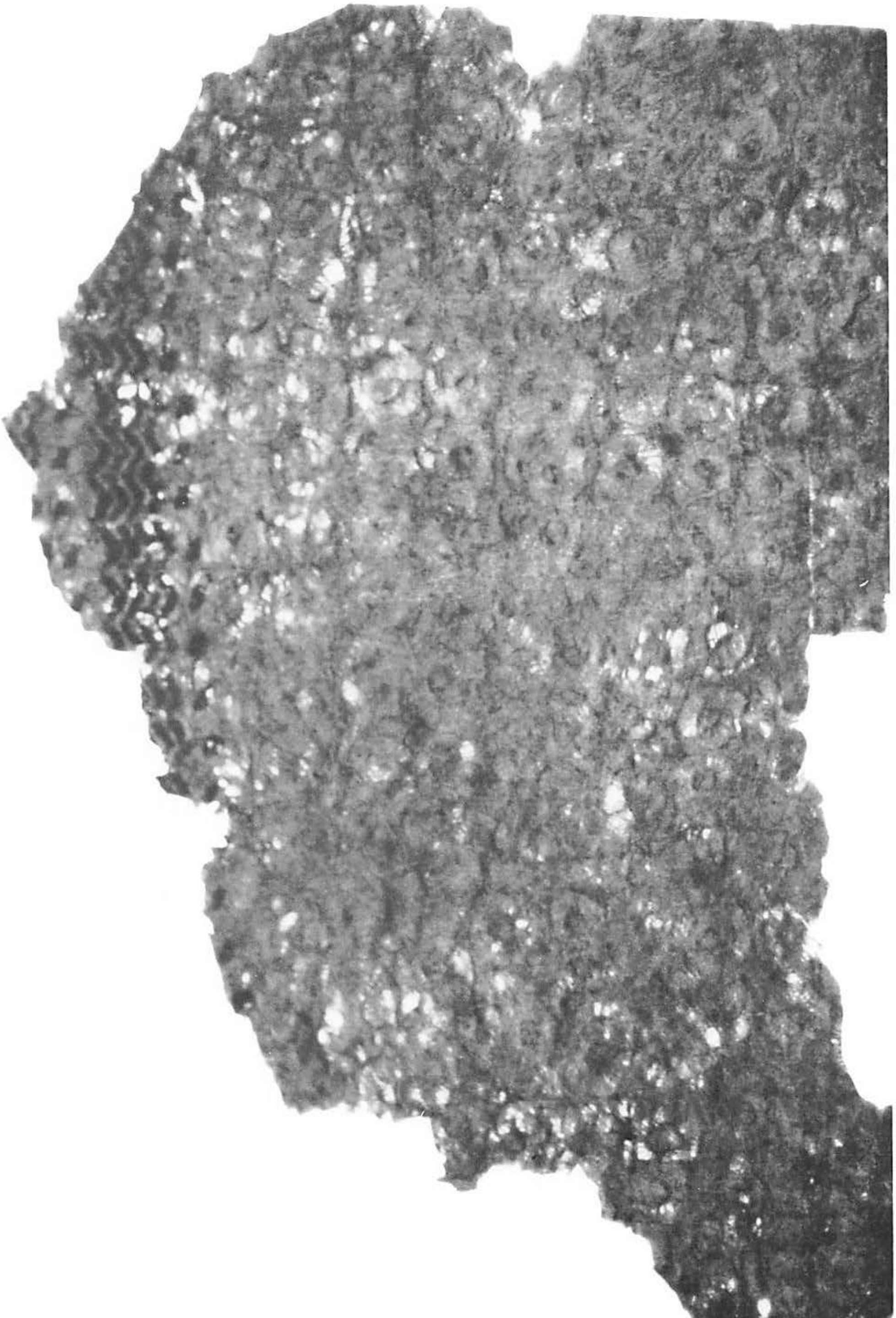
Characteristics of Oiled Tapa

Most Hawaiian tapa recognized as "oiled" in the Bishop Museum collection is made from paper mulberry (*Broussonetia papyrifera*), a small cultivated tree called *wauke* in Hawaiian. The majority of oiled specimens are single-sheet or multiple-layered *pā'ū,* women's skirts. Oiling is also found on two or three so-called *kapa māhuna,* tapa said to be used in some unknown way in sorcery. Museum specimens of oiled tapa are usually finely textured, frequently beatermarked, dull orange to pale yellow or golden brown in color, and sometimes elaborately stamped in designs of black or reddish tones. Apparently, they were often scented, too, although the fragrances have long since dissipated.

In summarizing the ethnographic literature, Kooijman (1972: 120) reports that Hawaiians used different parts of a variety of plants as agents for scenting dyes for tapa. Among them were roots as well as leaves of *kūpaoa* (*Railliardia scarba*), *nā'ū* (*Gardenia* sp.) flowers, and fronds of the fragrant *laua'e* fern—possibly the endemic relative of *Polypodium phymatodes* identified by Wagner (1950: 112) as *Microsorium spectrum.* The fragrant liquid (*wai'ala*) expressed from these and other plant preparations, according to the literature, was mixed with oil of roasted coconut meat and worked into a yellow turmericlike dye, which was applied to the barkcloth. *Malo,* or loincloths worn by men, were often treated in this way. Brigham (1911: 194) reports that *malo* worn by chiefs for bathing were soaked in *kamani* (*Calophyllum inophyllum*) nut oil infused with seeds of *ha'ā* (*Antidesma platiphyllum*). This was said to make the tapa more flexible, give it better color, and make it waterproof.

Over time, oiled tapa in the Museum collection has become stiff and often brittle. Edges break easily and cracks occur throughout the fabric (Fig. 11). The degradation of oils within the tapa is thought to be the cause of this brittleness. When oiled specimens are quite large, handling, exhibition, and even storage can cause further damage. A typical darkening and yellowing is also noticeable on Museum specimens of oiled tapa. This tendency has been corroborated by accelerated aging tests conducted on freshly beaten *wauke* samples treated experimentally with a variety of oils known to traditional Hawaiian culture, though not necessarily recorded in the literature as used on tapa. Because rice starch paste in combination with Japanese mulberry tissue does not adhere well to oiled tapa, standard mending techniques are not suitable for repairs.

Some tapas in the Museum collection show selective application of oil, or rather of a particular dye combined with an oil, possibly to make the color more permanent. Degener (1930: 198) reports that gum from the bark of the *kukui,* or candlenut (*Aleurites moluccana*) tree, when dissolved in water and brushed onto tapa, "protected the dye and made the cloth more durable and waterproof." The addition of oil would also produce a richer, more saturated color—another desirable quality—as well as impart a sheen or visual texture to the material. In certain examples the presence of an oil (gum or sap) can be seen in the



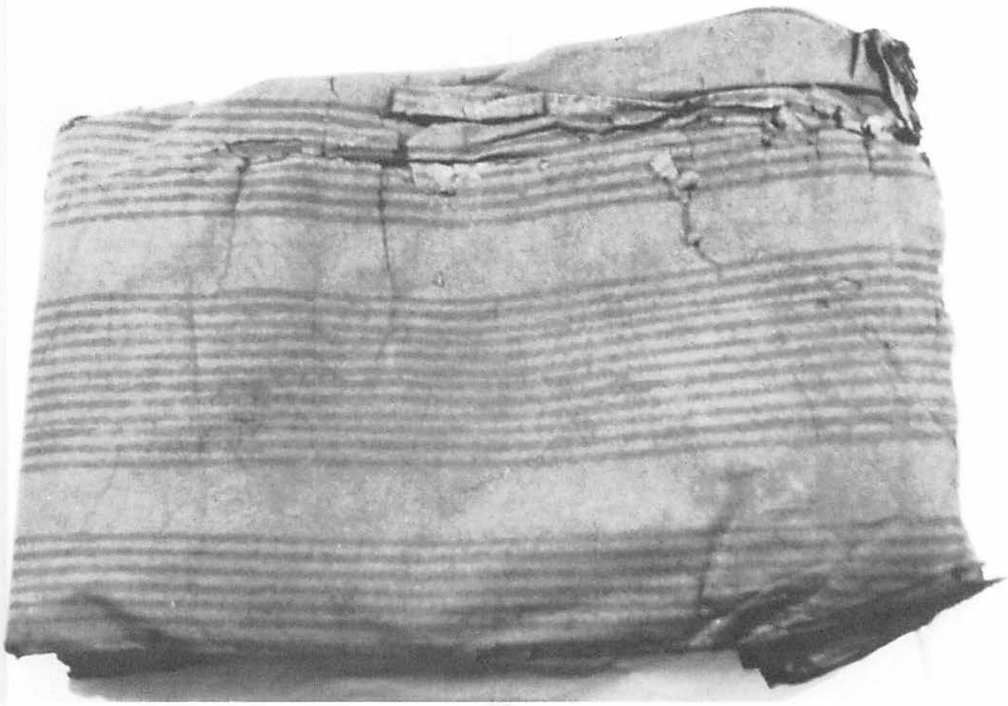


Fig. 12. Beaten from *māmaki* fiber, this five-sheet Hawaiian *kapa moe* (sleeping tapa) of typical design is too brittle to unfold (BPBM 2346).

shadow-effect surrounding specific design areas as well as in the resulting darkening and brittleness of isolated areas. In at least one instance the presence of crystals on the surface seems to suggest the presence of a degraded oil.

One specimen in the collection, apparently once colored overall with a yellow dye, now has only traces of yellow surrounding the dark brown stamped designs distributed in a pattern over the surface. Arranged also to form a wide border, the stamps apparently had been coated or the dye infused with an oil that was slightly absorbed by adjoining areas. Little of the border remains, due to extreme brittleness and resulting loss. The oil made the pigment "permanent" in one sense, yet severely damaging in another.

Characteristics of *Māmaki* Tapa

Māmaki tapa is made from *Pipturus albidus,* a wild nettle plant formerly widespread in forested areas of Hawai'i. Identified *māmaki* tapa in the Museum collection is almost always colored in shades of reddish brown or dark brown, usually with darker brown or black stripes applied over the solid ground color (Fig. 12). With relatively few exceptions the stripes are parallel and run the length of the sheet in varying widths and arrangements. Virtually no other form of applied decoration has been observed on *māmaki* tapa.

Māmaki tapa exhibits a consistency of manufacture not evident in other types of Hawaiian

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Fig. 11. Because of brittleness this fragment from a Hawaiian oiled tapa has become detached from a larger piece. The close-up reveals an unusually prominent beatermark for an oiled specimen (N/N-40c).

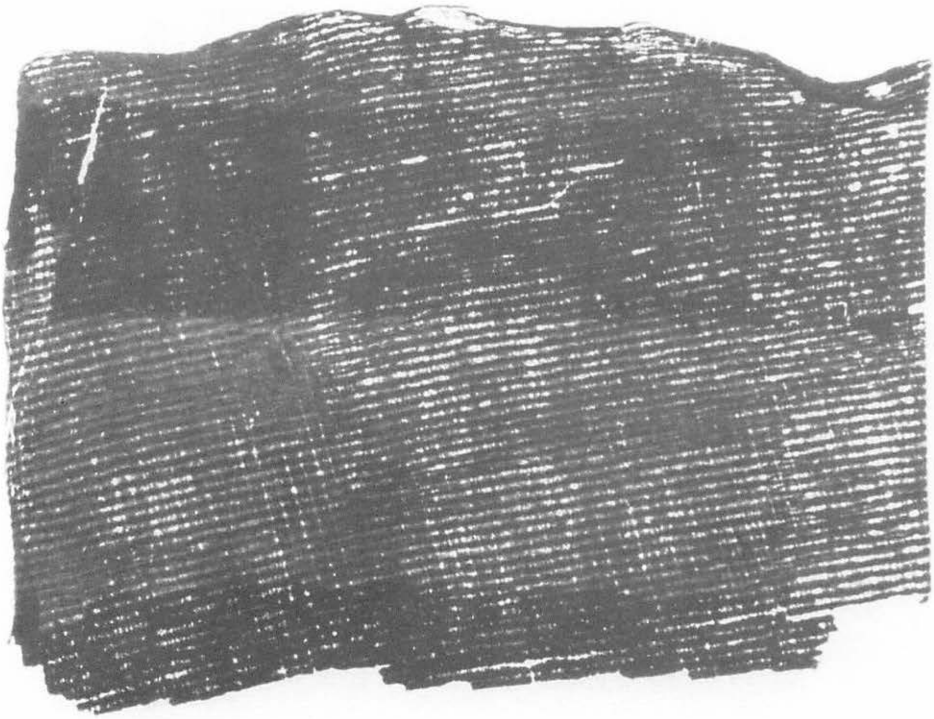

Fig. 13. Many Hawaiian *māmaki* tapa have a characteristic fine beatermark along which fibers tend to separate. This sample has been washed and lined with Japanese tissue.

tapa. Museum specimens are mostly very fine and delicate, with beater patterns often impressing a lacelike texture into the cloth. (On fine Hawaiian tapa a pattern resembling watermarks in paper is impressed into the cloth by carved wooden mallets during the final beating.) For whatever reasons, it appears that specific beater patterns are associated with *māmaki* tapa. Such "watermarks" frequently take the form of alternating parallel rows of clumped fibers and a network of single fibers (Fig. 13). It is along these thinner, weaker areas in the structure that breakage occurs during deterioration.

According to traditional (and sometimes conflicting) sources, *māmaki* yields a coarser and more durable tapa than *wauke.* Degener (1930: 132) reports that *māmaki* "produced the second best type of *kapa,*" and 19th-century Hawaiian historian Samuel Kamakau (1976: 115) observed: "Tapas made from *mamaki* were noted for their strength. They were made mainly on Hawaii, and not so much on the other islands." Another source states, "The tapa made at Waimea [Hawai'i] from *mamaki* bark was superior and in demand all over the island of Hawaii" (Judd 1932: 15–16).

There is also said to be a lighter colored *māmaki* tapa, more beige in tone, which has greater strength and flexibility. This is possibly the *māmaki* mixed with *wauke* (cf. Buck 1957: 168) described by Kamakau (1976: 115): "When *mamaki* was used on the other islands *wauke* was mixed with it; the result was an *aloalo* tapa." Kamakau (1976: 115) adds, "The best known of the *mamaki* tapas were the *'o'uholowai* and the *'eleuli,* dyed [scented] with *olapa* and *kupaoa.* They were fragrant and made splendid coverings and shoulder wraps, but *wauke* tapa was much warmer."

There is little recorded about the preparation of *māmaki* for tapa making. Though the shrub was plentiful, being one of the more abundant of the endemic fiber plants in the

Hawaiian Islands, its short and thin branches must have made preparation very labor-intensive. Once stripped of the outer bark and softened, an additive seems to have been necessary to help bond the many separate pieces of inner bark to make cloth. For at least some varieties of *māmaki* tapa the inner bark was steamed in earth ovens with *pala'ā* (*Sphenomeris chinensis*) fern, which yields a dark red dye (Malo 1951: 48). (One definition of *pala'ā* is "A tapa of *māmaki* bark dyed brownish-red with *pala'ā* fern, of silky quality" [Pukui & Elbert 1971: 282].) It is also claimed that mucilage from the *'ama'u* (*Sadleria cyatheoides*) tree fern was added to help hold the fibers together when beaten (D. Keawe, pers. comm. to N. Firnhaber; cf. Buck 1957: 167; Neal 1965: 23). We speculate further that it would have required considerable beating to produce a soft, malleable material that could be fashioned into very thin, uniform sheets such as those in the Museum collection. No contemporary artisan has been able to reproduce comparable tapa from *māmaki.*

These factors may account for the great value placed on *māmaki* tapa. The very specific character of this distinctive tapa, which in the Museum collection displays virtually no observed departure from prescribed beater patterns, color, design, and function, suggests that it occupied a special place in Hawaiian tradition—unless, of course, the physical limitations of the material itself account for these consistent treatments. According to Kamakau (1976: 115) and others, *malo* (loin cloths), *pā'ū* (skirts), *kīhei* (shoulder coverings), and *kapa moe* (sleeping tapas) were among the customary items made from *māmaki.* It is noteworthy, however, that with few exceptions the Museum's identified *māmaki* specimens are *kapa moe* or miscellaneous fragments and cave finds.

Māmaki tapa can become so brittle with age that it crumbles at the slightest handling. It generally has a lower pH than other tapa, and the very sheerness of *māmaki* tapa contributes further to its fragility. Since it appeared that consistency in the manufacturing process had resulted in deterioration that is also predictably consistent, research and testing focused on determining the source and causes of inherent weakness and deterioration in *māmaki* tapa. Generally speaking, the microstructure of the cloth appears to be the cause of its primary weakness, as the thin network of individual fibers linking adjoining rows of clumped fiber in the beatermarks is where breakage first occurs.

Tests Conducted on Oiled Tapa

Identification of oils

Like *māmaki,* oiled tapa becomes brittle upon aging. It yellows, darkens, and becomes translucent; fibers appear compressed and aged sheets have a crispness that resists folding and even handling. It is suspected that oxidation of oils catalyzes the oxidation of tapa fibers. As with paper, once embrittlement occurs strength and durability cannot be restored. Since oils are felt to be the major cause of deterioration of these tapas, identification of the oil(s) was a first consideration in our testing.

According to the literature, Hawaiians traditionally obtained vegetable oils from the coconut (*Cocos nucifera*) kernel, *kukui* (*Aleurites moluccana*) nuts, and *kamani* nuts. We obtained oils from these sources locally for experimentation. Coconut oil is available commercially with no apparent additives, as are both roasted and filtered *kukui* nut oil and roasted, unfiltered *kukui* nut oil. Both "false" and "true" *kamani* oils were tested. False *kamani* (*Terminalia catappa*), or tropical almond, was introduced to Hawai'i in the 1850s. Extracting oil from the true *kamani* (*Calophyllum inophyllum*) was not a simple process (Appendix D). Although no sources found mentioned animal fat application to tapa, the possibility was not ruled out. Because pigs were raised from prehistoric times in Hawai'i, pork fat was tested as well. Fish or shark oils could have been substituted as traditional sources of animal fat but we did not test them.

Accelerated aging tests were conducted on paper mulberry bast fiber that had been freshly harvested, fermented, beaten, and saturated with six collected oils. The purpose of these tests, conducted at the Department of Botany, University of Hawaii at Manoa, was to produce samples that could be physically compared to specimens of old oiled tapa in the Bishop Museum collection. A laboratory oven set to standards of the Technical Association of the Pulp and Paper Industry (TAPPI) was used for the accelerated aging tests. The standard is 100 °C for 72 hours, which is considered equal to 28 years of normal aging at a temperature range of 20–25 °C (68–77 °F). Three relative humidity (RH) standards were added to the heat-testing to simulate the probable high humidities to which tapa normally would have been exposed: 60%, 80%, and 100%. How they affected the proportional numbers of years of aging we did not know.

The following samples and oils were tested under dry heat (no added humidity), and 60%, 80%, and 100% RH: (1) two control samples of tapa: one with no oil but heat added, which would represent an *aged, unoiled* tapa, and one with oil added but no heat, representing an *unaged, oiled* tapa; (2) *kukui,* roasted and filtered; (3) *kukui,* roasted but not filtered; (4) coconut; (5) false *kamani*; (6) true *kamani*; (7) pork fat.

The results were as follows. All samples tested at 100% RH turned a uniform gray/brown. The samples subjected to no added humidity tended to be stiff; those subjected to 60–80% RH tended to be slightly more flexible. There was no noticeable difference between samples aged at 60% RH and those aged at 80% RH. In general, the samples treated with coconut oil were least similar in texture and appearance to old oiled tapa in the Museum collection, while the *kukui* oil- and animal fat-treated samples showed the greatest similarities in color and texture to the old tapa. (It must be mentioned that the newly beaten tapa used for the tests did not duplicate the delicate quality of old Museum specimens.) Though no turmericlike preparations as described above or other coloring or scenting material was added to the oiled samples, the samples with *kukui* oil and animal fat turned a golden yellow very similar to many of the typical oiled tapa in the Museum collection. None of the samples were brittle after the testing time. The samples treated with coconut oil felt oily, and oil could be rubbed off the surface. Since *kukui* is a drying oil, an oily or greasy residue did not remain; coconut oil tended to stay fluid. The other samples felt stiffer but not actually oily to the touch.

It should be noted that oil absorption into the papers on which old oiled tapa rests in storage still does occur. It is important, therefore, that oiled tapa be separated from nonoiled specimens and that there always be an interleaving layer of neutral tissues between.

Comparative analysis of oils and oiled tapa

To further the identification of oils in Museum specimens, tapa samples were submitted for fatty acid analysis (essential oils) to the Industrial Analytical Laboratory, Honolulu. Gas chromatography/mass spectrometry was used for this analysis and the results compared to known oils. The samples submitted were old oiled, old unoiled, and fresh unoiled paper mulberry tapa. The samples were analyzed for the presence of approximately 22 different fatty acids. Five essential fatty acids were observed consistently: methyl palmitate, methyl stearate, oleate, linoleate, and linolenate. Of these acids, palmitates and stearates are saturated and the other three are unsaturated. Table 1 lists the percentages of fatty acids found in the test samples of paper mulberry tapa. The percentages of these fatty acids in the tested oils are shown in Table 2.

The test results suggest that, over time, certain essential oils (fatty acids) in the unoiled tapa decrease as well as change in relative proportion. The fresh unoiled tapa sample begins with a high percentage of methyl stearate and over time the stearate decreases and oleate and linoleate increase. This is very interesting in that a high percentage of unsaturated fatty

Table 1. Fatty acid analysis (essential oils) of selected paper mulberry tapa samples.

	Fresh unoiled (%)	Old unoiled (%)	Old oiled
Methyl palmitate	14	4	Detectable and major component
Methyl stearate	59	5	Detectable
Oleate	5	56	Trace
Linoleate	13	35	Trace
Linolenate	9	1	Trace

acids (oleate and linoleate) occur in the old unoiled specimens, whereas the fresh (unoiled) fiber is fairly low in unsaturated fat and high in saturated fat, particularly methyl stearate. This was not an expected result and adds more intriguing questions about the indigenous treatment of "oiled" tapa.

Old oiled tapa has detectable amounts of two saturated oils, palmitate and stearate, and only trace amounts of the remaining unsaturated fats. This would seem to indicate that oil may not have been applied to what we have called "old oiled" tapa, but that some other component was used that gives it its unique characteristics. Alternately, the results could suggest that an oil of a saturated nature was applied to the old tapa, such as animal fat, which is high in stearates. Speaking generally, unsaturated fats are more prone to biodeterioration and less likely to remain than saturated fats.

pH testing and washing

The pH range of oiled tapa was determined through the use of acid-base indicator strips and an electrode pH meter. In five tested samples the range was 4.0–4.7. A sampling of six other pieces provided an average pH of 4.3.

Samples from two oiled tapas were subjected to washing.[5] The first was one of many segments that had been cut from the same specimen and stored in an old volume of tapa samples. The segments still showed considerable flexibility and were smooth-surfaced, yellow-orange in color, and had an "alligator" beatermark that was quite prominent. A pH of 4.0 was measured with indicator strips before washing, which is typical of old oiled tapa. The sample was washed for ½ hour in changes of lukewarm water. There was no visible runoff in the water and the sample appeared to be saturated after a few minutes of soaking. After air drying it appeared to be even more flexible than an identical, unwashed sample and was softer to the touch. The beatermark seemed to have been raised by wetting, as the surface was not so smooth or compressed. The pH after washing was 6.0.

The second, a very thin, brittle oiled sample, red-brown in color with a stamped design and prominent, round beatermark, was washed in *very* warm water for a much longer period of time (1 hour 15 min). There was considerable loss of yellow color with each successive change of water. This treatment proved to be excessive and damaging as there was loss of oil in areas where the beatermark was thinnest, producing an unpleasant mottled effect. After drying the sample appeared "rusty" in color. The loss of color was probably due to the high temperature and long duration of the wash; there was no compensating improvement in flexibility (pH 4.0 before, pH 5.5 after washing).

Another sample from the same tapa was cut into four sections, three of which were washed, one for 20, one for 40, and one for 60 minutes in lukewarm water. This time

5. Tap water was used for washing and had a pH of 7.0, measured with an electrode pH meter, and less than 0.02 ppm of iron, manganese, copper, lead, arsenic, selenium, and chromium; other properties include bicarbonate, 71 ppm; magnesium, 13 ppm; and calcium, 12 ppm.

Table 2. Percentage of fatty acids (essential oils) in theoretical tapa oiling agents.

	Kukui (%)*	Pork fat (%)	False *kamani* (%)	True *kamani* (%)	Coconut (%)
Methyl palmitate	5	30	9	1	7
Methyl stearate	3	14	34	10	13
Oleate	20	41	57	19	12
Linoleate	42	7	1	70	3
Linolenate	29	3	1	1	0

* Corroborative results for *kukui* nut oil analysis was obtained in 1974 by the Applied Biological Sciences Laboratory of Glendale, California, and the University of Hawaii at Manoa, respectively, as follows (figures expressed in percentages): palmitic 6.3, 7.7; stearic 2.8, 2.5; oleic 18.4, 13.6; linoleic 47.8, 51.8; linolenic 24.7, 23.8 (Coryell 1985).

there was no runoff and no visible change in the color of the samples. There seemed to be a progressive increase in softness and flexibility and a very slight rise in pH as determined by meter with each increase of wash time, as follows: Control (not washed) pH 4.95; 20-min wash, pH 5.25; 40-min wash, pH 5.43; 60-min wash, pH 5.60.

Adhesive testing

Three samples of oiled tapa were subjected to a variety of solvents to test adhesive bonding and reversibility. Two tests had been conducted three years previously during Phase II of the tapa project. Combinations of adhesives that provided both good bond for repair tissue to oiled tapa surface and easy reversibility were selected for further testing. Removal of a repair with water and minimum manipulation with a spatula is preferable to the use of organic solvents.

In previous phases of the project, tests were conducted to find an adhesive more appropriate for oiled tapa than rice starch paste. Ideally, the adhesive should adhere to the oiled surface as strongly as starch paste adheres to unoiled tapa, remain flexible, be easily reversible, and leave little to no residue in the tapa itself. Early test repairs were documented and could be compared along with the new tests against these requirements. In all, six different adhesives in various combinations were tried with Japanese paper mulberry tissue, and reversibility was tested for each. The release tests involved the application of water to soften and release the bond; use of a microspatula to lift fiber edges of a mend; and removal with organic solvents.

Table 3 indicates the results of the reversibility tests. The solvents were applied on a cotton swab, which was rolled over the mend to saturate the mend but not the tapa. If a mend could be removed mechanically without use of a solvent (indicated by a "+" in the Table), solvent was not used. Some adhesives were released by water, but not immediately ("+−" in Table). More thorough saturation of the solvent may have been required. For example, CM Bond M-4 with Klucel H released with water, but the feathered edge fibers of the mend remained quite firmly attached to the tapa. Acetone then easily released the edge fibers. The combination of both solvent-soluble and water-soluble adhesive was used to try to achieve good adherence to oiled tapa and also easy removal. Tests indicate that the combination worked very well.

A very thin, extremely brittle, and breaking tapa sample with elaborately stamped designs was chosen for repair with CM Bond M-4 and carboxy-methyl cellulose (CMC) 1:1. The repair tissue was toned. It was pasted up with this adhesive combination and tamped down, as are mends with starch paste, then dried under weights. Mends adhered smoothly and securely and the specimen was greatly stabilized by the repairs. Two other adhesive combinations that adhered as effectively have not, beyond initial testing, been applied to spec-

Table 3. Results of reversibility tests with selected adhesives on oiled tapa.*

Adhesive	Release agent			
	Mechanical	Water	Acetone	Toluene
Wheat starch paste	+			
Carboxymethyl cellulose	+			
Klucel H (hydroxypropyl cellulose)	+			
Klucel H with rice starch paste 1:1	+			
CM Bond M-4 (polyvinyl acetate copolymer emulsion)	−	−	+	+
CM Bond M-4 with starch paste 1:1	−	+−	+	+
CM Bond with Klucel H 1:1	−	+−	+	+
CM Bond with CMC 1:1	−	+−	+	+
Rhoplex AC 33 (acrylic emulsion)	−	−	+	+
Rhoplex AC 33 with starch paste 1:1	−	−	+	+
Rhoplex AC 33 with CMC 1:1	−	−	+	+
Rhoplex AC 33 with Klucel H 1:1	−	+−	+	+
Library of Congress Heat Melt (Rhoplex AC 73 and Plextol B500 emulsion)	−	−	+	+

* "+" indicates full release of the adhesive. "+−" indicates that the adhesive was released by water but not immediately. Water scoring "+−" was followed by an organic solvent, which achieved full release of long "feathered" fibers.

imens in the collection. They are CM Bond M-4 with Klucel H 1:1 and Rhoplex AC 33 with Klucel H 1:1. Both are reversible with water and minimal manipulation. Toned papers were also tested to determine if the acrylic wash applied as tone to Japanese tissues would inhibit adhesion. This did not appear to be the case.

Use of consolidants

Consolidants to increase the flexibility of stiff and often brittle oiled tapa were tested. Generally speaking, it is not desirable to introduce a new penetrating substance into the fibers to lubricate them temporarily. Nevertheless, as a controlled experiment several consolidants that might increase the flexibility of oiled tapa were tested.

Polyethylene glycol (PEG), 1,500 molecular weight, was applied to a section of tapa. The test area became much more flexible and translucent and stayed moist for several weeks, but some of the color of the tapa transferred to the blotting paper it was resting on. After several months the area was still apparent and flexible. Adhesives, however, did not adhere well to the area. Two years after the PEG was applied, the test area was no longer apparent but the tapa was still quite flexible.

Klucel H, hydroxypropyl cellulose, was also applied to a test area. This compound is characteristically transparent, flexible, and soluble in water and organic solvents. Several applications were brushed on. This made the tapa seem a little stronger and "thicker" but it was not flexible.

In one sample of old oiled tapa the oils were completely extracted with hexanes. This made the tapa softer and more flexible and the original color remained; however, it radically changed the character of the cloth, which no longer resembled an oiled tapa.

Tests Conducted on *Māmaki* Tapa

pH testing and acid analysis

Surface pH readings of *māmaki* tapa were taken with acid-base indicator strips, and a glass electrode pH meter was used to produce readings from cold-water extractions. The pH range was found to be between 3.8 and 5.6, with readings most frequently around 4.4.

This shows that a highly acidic condition exists and that it is either inherent in the manufacturing process or catalyzed by other conditions, such as heat and moisture. Measurement with pH indicator strips was difficult because of the uneven surface of *māmaki* tapa (due to pronounced beatermarks) and because of the soluble nature of the coloring matter absorbed by the strips.

Māmaki tapa was analyzed for type of acids present, again at the Industrial Analytical Laboratory. Acids were extracted using distilled water and ultrasonification, and the analysis was performed with an ion chromatograph. A predominance of oxalic acid was found, about 1,000 times more than in fresh *māmaki,* suggesting that the old *māmaki* tapa had been saturated in a concentrated solution of oxalic acid.

Māmaki samples were also tested using phloroglucinol in methyl alcohol and hydrochloric acid for presence of lignin and for acidity, both with Barrow spot test solutions. The deep brown coloration of the tapa, however, made it difficult to assess the degree of the responses, although the spot tests for lignin stains appeared to be more yellow than magenta, suggesting a positive reaction. The test for acidity was not conclusive for the same reasons, though there were positive reactions on all samples tested.

Two hypotheses might explain the deep brown color of *māmaki* tapa. One suggests that the fiber itself darkens naturally as it is soaked in water or exposed to air during processing. The second hypothesis suggests that the tapa was immersed at some point during manufacture in taro patch mud, which is rich in iron compounds. If lignin and iron compounds are present together in *māmaki* tapa (lignin is known to bond firmly with iron), they may be responsible for its high acidity and severe deterioration. Further experimentation is necessary to answer these questions.

Washing and deacidification

Tests were conducted on *māmaki* tapa to determine if safe deacidification could be accomplished by washing in water. Three small samples of *māmaki* tapa with varying coloration and beatermarks were selected. Untreated sections of each sample were kept as controls after treatment. Samples were individually immersed in warm water; there was an immediate run-off of brown-black color. Subsequent changes of water resulted in progressively reduced intensity of run-off color. Each sample was washed for a period of one hour. Increases in pH after washing were observed for each of the three samples: 4.3 to 5.5, 3.2 to 5.3, and 3.6 to 4.7. The samples seemed slightly more flexible after drying and there was a subtle shift in background color toward a blacker brown from a redder (rust) brown. The black color of the stripes remained visually unchanged. After air drying, the beatermark ridges returned to their prewashed state. Further investigation into the nature of the run-off, specifically whether it shows presence of iron, still remains to be done.

Because of the physical condition of much of the *māmaki* tapa in the Museum collection (large size of sheets, multiple layers in some specimens, fragile state of the cloth), washing may not be a viable preservation treatment. Consequently, the difficulty involved in safely buffering a large, deteriorating tapa in an aqueous bath suggested the need for testing a nonaqueous deacidification solution.

Some *māmaki* tapa samples had been buffered in earlier phases of the tapa project with an aqueous solution of calcium hydroxide. Wei-T'o spray #11 (Wei-T'o Associates, Park Forest, Illinois), which deposits magnesium ethyl carbonate in the fibers, was applied to a relatively small, manageable specimen before lining (Fig. 14, 15). The tapa was extremely fragile and torn, so wet treatment was entirely out of the question. The solution was sprayed repeatedly over the cloth to assure uniform coverage. Although efforts to measure pH before and after with pH indicator strips were not completely successful due to solubility of the color and the uneven surface of the lacey tapa, it appeared that the pH had been raised

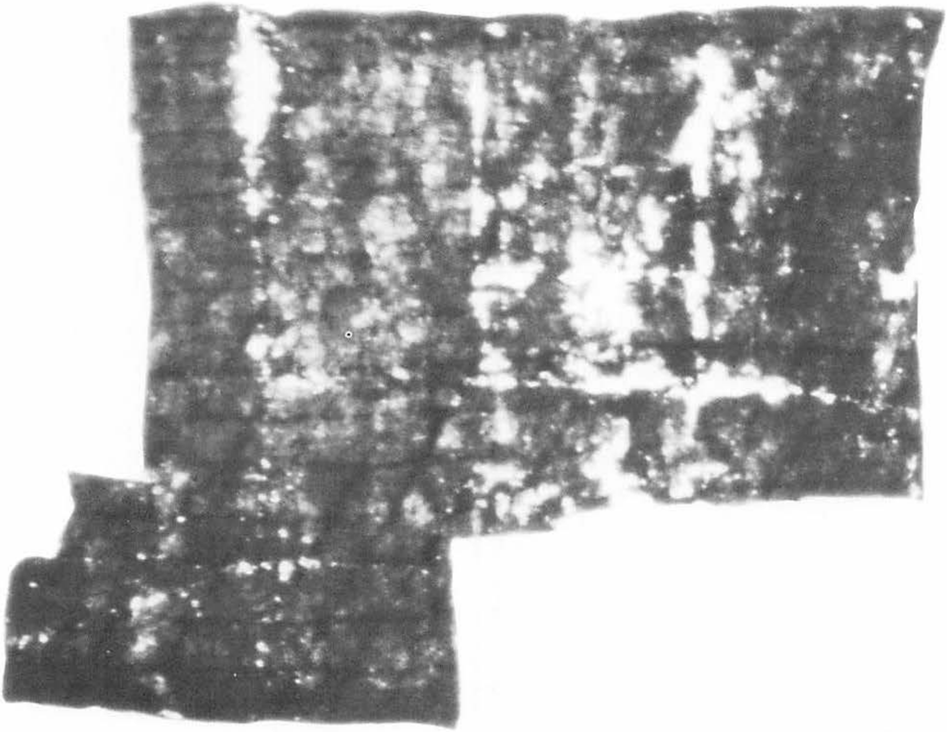

Fig. 14. After careful unfolding, this delicate Hawaiian *māmaki* tapa fragment with numerous losses is shown prior to conservation (BPBM 2531).

considerably by the spraying. Further tests are necessary before this treatment can be recommended for general use.

Artificial aging

Freshly beaten *māmaki* bast fiber was artificially aged to check pH using the same method as with oiled tapa. Fresh *māmaki* has a pH of 5.0–6.0. The pH after aging was 5.6, though the sample turned stiffer and darker than the control. A sample of *māmaki* with *Sadleria* fern mucilage added was also aged. Fresh mucilage has a pH of 5.0. The specimen also became stiffer and darker, with a post-treatment pH of 4.0–5.0. It should be noted that it is much more difficult to make new *māmaki* tapa that approximates the quality of Museum specimens than it is to manufacture new *wauke* tapa of equivalent quality.

Repair materials for *māmaki* tapa

A variety of adhesives and repair materials were aged and tested for their suitability in repairing and lining *māmaki* tapa. Of those tested, two sets of support materials and adhesives were selected as possible repair combinations: *kizukishi* (similar to *tengujo* tissue) with rice starch paste, and nylon gossamer with an acrylic emulsion (Heat Melt adhesive formulated by the Library of Congress).

Rhoplex AC 73 and Plextol B500 emulsions (750 ml : 500 ml) in a 10–15% diluted solution was lightly coated on a nylon gossamer support and applied to the back of a *māmaki* sample with a tacking iron. This backing seemed to hold well, added negligible thickness, did not alter the beater pattern, and did not appear to change the flexibility. It gave overall strength but also added an undesirable opacity to the side of application. The adhesive is

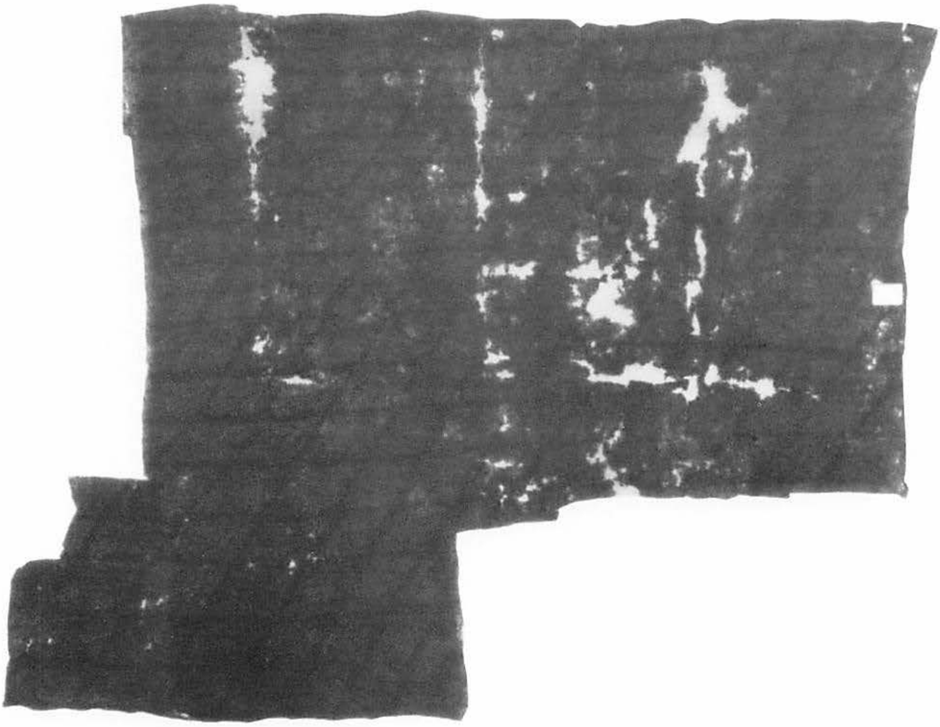

Fig. 15. After buffering with Wei-T'o spray #11, the *māmaki* tapa fragment shown in Fig. 14 has been lined on the verso with Japanese tissue affixed with rice starch paste and is now stabilized.

removable with the reapplication of heat and is soluble in acetone, alcohol, or toluene. The acrylic application seemed, however, a less desirable solution because of the opacity that resulted, because it reverses only with organic solvents rather than water, and generally because it seemed less complementary to the natural material of the tapa.

Thinner and more transparent than nylon gossamer, the long-fibered Japanese tissue *tengujo* was selected for testing with rice starch paste. This tissue was successfully toned with washes of acrylic pigment that permitted a greater degree of transparency when applied to tapa. The toned tissue was used to repair breaks in *māmaki* tapa samples or to line or reinforce them fully on the verso. The act of tamping down the pasted tissue with a soft Japanese brush brought tapa and tissue fibers into closer contact than was possible using the acrylic attachment with a tacking iron. The thin *tengujo* tissue did not alter the character of the tapa. It was still possible to see the beatermark through transmitted light (particularly with toned tissue), and the tapa retained a great deal of its unlined flexibility.

Artificial or accelerated heat aging tests were also performed on the various backings and media that were considered for repair of *māmaki* tapa. These tests were conducted in a dry oven, maintaining a 100 °C temperature. The results are shown in Table 4.

SUMMARY AND CONCLUSIONS

Phases I and II of the tapa project were designed to consolidate and stabilize endangered specimens in renovated, systematic storage in order to prevent further damage or loss due to natural deterioration caused by fragility and age. A corollary goal, also achieved, was to bring the bulk of the Bishop Museum tapa collection to a condition that would permit safe

Table 4. Artificial heat aging tests performed on selected materials used in tapa repairs.

Test samples	Physical characteristics of test materials	
	Before	After
Supports		
Japanese papers: *Kizukishi* natural, *Seikishu* natural	White, pliable	Light brown, minimal tear resistance
Nylon gossamer	White, pliable	Light beige, remained pliable and strong
Polyester webs, commercial samples	White, pliable	Discolored, remained pliable and strong
Silk crepeline, sized	White, pliable	Dark brown, brittle
Silk crepeline, washed, size removed	White, pliable	Beige, slightly less pliable
Nylon net	White, pliable	Light beige, pliable
Adhesives, consolidants		
Rice paste	White gel	Light brown, hard
Rice paste liquid	White, thick liquid	Off white, transparent film
Polyethylene glycon MW 1500	White, waxlike	Clear, greenish liquid
Coconut oil	Clear liquid	Clear liquid
Carboxymethyl cellulose	White gel	Gray, hard mass

handling for research and exhibition. Investigations of special problems and questions affecting Hawaiian oiled and *māmaki* tapa, and testing of conservation materials and techniques essential to their preservation, were undertaken during Phase III of the project.

Oiled Tapa

We investigated the oils found in what traditionally have been referred to as "oiled" tapa in the Bishop Museum collection. Although there is some variation in their condition, all the oiled tapa are brittle to some degree. A few heavier, beatermarked examples have retained some flexibility but the thinnest appear to be the most brittle, fragmenting much as brittle papers do. The oil analysis suggested that *kukui* nut oil may have been used as the primary oiling agent.[6] The analysis is preliminary and points to the need for identification of trace elements remaining in old oiled tapa and a better understanding of the ratio of saturated to unsaturated fats. Research and testing provided various solutions to the problems of repair, though some questions regarding these special treatments are not fully answered.

Testing of adhesives for the repair of oiled tapa provided some effective alternatives and at the same time a possible method of consolidation by lining. Because of oil residues in this variety of tapa, it cannot be repaired with water-soluble pastes. Therefore, several adhesives soluble in a combination of water and organic solvents were tested and four were found to provide both a good bond and easy reversibility with water and a minimum of manipulation: CM Bond M-4 with starch paste 1:1, CM Bond M-4 with CMC 1:1, CM Bond M-4 with Klucel H 1:1, and Rhoplex AC 33 with Klucel H 1:1. Water was preferred to organic solvents when removal became necessary.

Repairs using these adhesives were made with thin Japanese tissue applied in the same manner as those with starch paste. When necessary, linings were applied using toned *tengujo* tissue with a very dilute paste combination. *Tengujo,* a very thin, pure paper mulberry tissue was found to be the ideal support tissue for lining oiled tapa. It was toned, pasted up with one of the four successfully tested adhesive combinations (over mylar), transferred to the

6. Since this work was completed, further analysis of oiled tapa has been undertaken by David Erhardt of the Conservation Analytical Laboratory, National Museum of Natural History, Smithsonian Institution. Results, which are expected to show that *kukui* nuts are the probable source of oil in oiled tapa, are forthcoming.

verso of the tapa, then tamped down in the manner that tapa repairs are generally adhered. Though lining of a full-sized oiled tapa was not attempted, on the basis of information obtained in research and testing, we consider it the best method of consolidation available when the tapa is so brittle as to require reinforcement.

Restoring flexibility to oiled tapa will always be problematical as it requires consolidation of the tapa or removal of the oils, both of which might restore flexibility but also alter the tapa's integrity. Nevertheless, three approaches were investigated to see if flexibility could be restored to brittle oiled tapa: (1) extracting the oil, (2) introducing a lubricating agent into the cloth, and (3) restoring hydrogen bonding of cellulose molecules in fibers by washing in water. We consider both additive (lubricant) and subtractive (extraction) approaches to restoring flexibility to oiled tapa inappropriate. Perhaps in the future other methods or these methods with other substances will prove more successful than those tested. It must be noted that we cannot know with any certainty the original character of old Museum specimens of oiled barkcloth.

Immersion in water may prove beneficial upon further testing. Washing of oiled tapa samples demonstrated that some flexibility can be restored. This may be a more useful treatment for oiled pieces that still possess limited flexibility. Fibers seem to swell slightly and to appear less compressed as a result of water washing.

The shortage of expendable old samples available for experimentation and possible destruction was a limitation. Results were sometimes subjective, dependent upon visual comparison and the sense of touch. A larger sampling should be done and consistent techniques for measuring changes devised. Microscopic examination as well as comparative fiber analysis of the tapa collection itself may uncover new data.

Māmaki Tapa

A better understanding of the physical and chemical properties of *māmaki* tapa was reached, though we feel that certain presumptions remain unsubstantiated. We know that an acid condition exists that must be neutralized, and both physical and chemical factors make *māmaki* tapa fragile upon aging. The lacey, thin network of beaten fibers and inherent acidity stemming from sources not fully understood cause surviving Museum examples of *māmaki* tapa to be very delicate, brittle material.

Water washing is a treatment as beneficial for tapa as it is for degrading papers, but only if the specimen's condition and size permit immersion. Washing *māmaki* samples reduced acidity somewhat and gave them a slightly softer feel. Since the brittle condition cannot be reversed, these treatments would be most beneficial in cases where tapa is still flexible (as with examples that may be combined with *wauke,* or paper mulberry fiber). An alkaline solution may be introduced with an aerosol if the tapa cannot be bathed and neutralized in water.

Repairs to *māmaki* tapa can be very extensive since it tends to break readily in the very thin portions of the beatermark. We found the best possible repair and lining material for *māmaki* tapa to be the thinnest, and this was again the Japanese tissue *tengujo. Tengujo* has very long fibers and, despite its delicacy, can be toned so that it is less opaque, allowing fullest possible recognition of the distinct qualities of *māmaki* tapa. With *tengujo* the beatermark may be seen by transmitted light even after lining. The tissue was applied to the tapa with a thin rice starch paste and tamped or lightly pounded with a book binder's brush to achieve good bond of paper to tapa fiber.

The combination of techniques and materials developed for repair of unoiled paper mulberry tapa will continue to be used, and we will continue to experiment with techniques and materials that seem most promising for the conservation and repair of oiled and *māmaki* tapa.

ACKNOWLEDGMENTS AND CREDITS

The National Science Foundation (NSF) generously supported three ongoing phases of the tapa project: Phase I, Renovation of Bishop Museum Hawaiian and Pacific Barkcloth Facilities (BNS 78-10540, 1 October 1978 to 31 March 1980); Phase II, Renovation and Conservation of the Bishop Museum Tapa Collection (BNS 81-05387, 1 April 1981 to 30 September 1982); and Phase III, Conservation and Research into Special Problems of the Bishop Museum Tapa Collection (BNS 83-8156, 1 July 1983 to 31 December 1985). Dr. Roger G. Rose served throughout as Principal Investigator.

During Phases I and II of the project, Linnea O. Brown coordinated the orderly transferral of some 3,200 tapa specimens from old to new storage facilities. She assessed and rated all specimens for physical condition, updated catalog records, and coordinated photographic activities, including cataloging and arrangement of some 3,250 slides and photographs during Phase III of the project. She also assisted with the remedial conservation of barkcloth specimens, made tapa for experimentation, and offered many valuable insights into the project as a whole. She was fully supported by NSF throughout all three phases of the project.

Dora Jacroux, Betty Long, and Laura Carter, Ethnology Curatorial Assistants at different times during the three phases of the project, contributed their expertise and assistance in various ways, not least day-to-day coordination with other ongoing Museum activities. They were assisted by Catherine C. Summers, Honorary Associate in Anthropology, and Dorothy B. Weight, volunteer, throughout the course of the project.

During Phase III of the project Mary Wood Lee, then Chair of the Pacific Regional Conservation Center, worked with David Bean, visiting paper conservator from the Library of Congress, to conceptualize and initiate some of the experimental portions of the project. This work was later carried on by Laura J. Word, now Chair of the Pacific Regional Conservation Center, and Carol Turchan, currently Conservator at the Chicago Historical Society. Both Bean and Turchan worked directly with Natalie Firnhaber, Objects Conservator of the Pacific Regional Conservation Center (now Conservator at the Anthropology Conservation Laboratory, National Museum of Natural History, Smithsonian Institution).

The results of the experimentation reported herein is largely the work of Turchan and Firnhaber conducted during Phase III of the project. They concentrated on oiled and *māmaki* tapa, particularly in determining the nature and composition of the oiling agent and in the testing of materials used in the conservation of these problematical specimens. Bean, Turchan, and Firnhaber also trained or helped oversee the daily activities of the volunteer corps engaged in the remedial treatment of selected barkcloth specimens (Appendix A). Both Bean and Turchan were fully supported by NSF during Phase III of the tapa project; Firnhaber was funded one-half time.

A remarkable corps of volunteers contributed materially to this project. During Phases I and II these were Rhonda Annesley, Pam Jaasko, Francine Kemp, Marty Norton, Evangeline Otsuka, Lisa Reh, Oma Umbel, Christine Valles, and Arenda Weishaupt. During Phase III volunteers included Dr. Isabella A. Abbott, Linda Bussell, Betty Cook, Helen Fecenko, Linda Hee, Virginia Koch, Pamela Lipscomb, Nancy McMahon, Marcia Morse, Susan Pertel, Ann Cotter Ross, Jean St. John, Susan Shire, Barbara Stephan, Leann Woodward, and Sheila Woolcock. Other volunteers, staff, and special visitors who contributed as time permitted include Laura D'Alessandro (Pacific Regional Conservation Center Mellon Fellow), Rosemarie Chang, Toni Han, Rhoda Komuro, Manouche LeHartel, Leslie Paisley, Mary Pritchard, Malcolm K. Smith, and Malia Solomon. We are indebted for their enthusiastic support.

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APPENDIX A

TRAINING VOLUNTEERS FOR TAPA REPAIR

Repair of tapa requiring remedial as well as more specialized conservation began with the training of volunteers to help perform routine mending during Phase III of the project. Volunteers were supervised by conservators who worked with them and supplied technical information as necessary.

Volunteers were initially recruited from three sources: the Bishop Museum docent program, the University of Hawaii, and a private craft school. Four artisans from the Temari Center for Asian and Pacific Fibers had made long-term commitments to tapa making and were eager to have "hands-on" supervised experience with Museum specimens of 18th- and 19th-century barkcloth. Two other volunteers were anthropology students at the University of Hawaii at Manoa and another was a long-time docent at both Bishop Museum and 'Iolani Palace.

Recruiting was done through the Temari Center and the Bishop Museum newsletter *Ka 'Elele.* Volunteers were screened through interviews and reference checks since a one-year commitment was required because of the nature of the training and the need for continuity. Applicants were accepted on a trial basis: if after training and two weeks' practice they did not like the work, or if their work proved unacceptable, they would be dropped. Fortunately, all did satisfactory work and were reliable, even making up time for absences. They were trained in sessions scheduled throughout one week that included two half-days per volunteer. Initial training was in the fundamentals of paper conservation; on-going in-service training followed.

Unfortunately, Phase III of the project had to be temporarily suspended after less than six months when one of the conservators became ill and could not be immediately replaced. Many of the volunteers had developed a degree of expertise and were disappointed when they could no longer continue to use their skills. When the project resumed, only two of the original volunteers were able to rejoin the program, one only briefly. Again, recruitment was done through the Museum newsletter *Ka 'Elele* and notices were run in a Honolulu newspaper. Selection and training were streamlined in order to fully utilize the remaining six months of the grant period. There were no preliminary interviews or reference checks, and each volunteer was given only one half-day training session, with provisions for in-service training. All willing volunteers were accepted until a quota was reached. This time a six-month commitment was requested and there was no initial trial period.

Volunteers during this phase included three paper-makers, an ethnobotany professor, an art student, a housewife with a degree in art history, an archaeology student, a tapa maker with over 20 years' experience, two long-time Museum volunteers, and a staff archaeologist. There were others who failed to return after training or who dropped out after a few weeks. It appeared that the high rate of attrition during the second session was a result of compromises during the screening process. Of the volunteers who remained, the quality of workmanship was uneven.

For similar future projects it is recommended that volunteer applicants be screened both for reliability and manual dexterity.

APPENDIX B

FORMULA FOR RICE STARCH PASTE FOR TAPA REPAIR

100 ml rice starch (Conservation Materials, Inc., Sparks, Nevada, and other suppliers)

600 ml distilled water

Prepare paste in an enamel, stainless steel, or glass double boiler. In a small bowl, add a small portion of the distilled water to the rice starch and stir thoroughly to combine. Heat the remainder of the water in the top of the double boiler until it begins to bubble around the bottom of the pan, but do not boil. Pour starch slurry into the heated water, stirring at the same time.

Continue to stir the mixture and cook for about 20 to 30 minutes over medium heat. The paste will become translucent and thicker and drop from the spoon in sheets. Remove from heat when sufficiently cooked and set into a container of cold water to cool. Change the water several times to aid in cooling. When the paste no longer feels warm to the touch, strain it through a fine-meshed Japanese horsehair strainer or equivalent utensil such as found in gourmet kitchen supply shops. Store in an airtight container.

The paste should be refrigerated and small portions used as needed. It is not advisable to add a fungicide directly to the paste. Instead, dampen a small piece of blotter paper with a fungicide, such as 2% thymol in ethanol, and place it in the top of the storage container. The paste tends to last for a week this way.

To prepare for use, the paste must be diluted and blended with water to the proper consistency, depending on use and individual preference. Strain the portion of paste required through the horsehair strainer into a glass baking dish. Slowly add distilled water and with a Japanese paste brush knead the paste, working the water into it and smoothing it to a workable consistency that is devoid of lumps. For most purposes the consistency should resemble that of whole milk. Transfer to a covered container for use.

APPENDIX C

TONING TISSUE FOR TAPA REPAIR

Acrylic pigments	Japanese tissues
2-inch flat Japanese brush	Sheets of mylar (larger than tissue)
Distilled water	Bristle brush

Use only *water-soluble* acrylic pigments (such as Liquitex brand) in a variety of earth tones: burnt umber, raw umber, raw sienna, burnt sienna, black, red oxide. Sometimes brighter yellows and reds are needed to achieve a desired color.

Mix color in a jar or beaker with a stiff bristle brush and a small amount of water. It is difficult to determine how much color solution will be needed, as it depends on the amount of tissue to be toned and how deep the tone is to be. It is better to make more than needed than to attempt to mix exactly the same color again. Make test spots on the same type of tissue as that to be toned. The tone will dry considerably lighter.

Japanese tissue is delicate when wet. It is best to support the sheet of tissue with mylar when brushing on color. Dampen the tissue first by misting so that brushmarks are not formed when color is applied. Brush color on lightly with a soft, flat Japanese brush in one direction. Do not disturb the paper fibers by rubbing the brush over the paper surface. It may be necessary to reapply the toning solution 2–3 times, letting the tissue dry between each application, in order to achieve a deep color.

Allow the tissue to dry only partially on the mylar support (longer for *tengujo* because of its poor wet strength). Then pull away carefully from the mylar and place on blotters or drying rack to continue drying. There will be some transfer of color. The mylar should be cleaned after toning each sheet. All edges of the sheet should be water torn after drying for lining. The more pigment used, the more the character of the tissue will change with the introduction of the synthetic resin. This will not affect its repair potential.

APPENDIX D

OIL EXTRACTION FROM *KAMANI* (*CALOPHYLLUM INOPHYLLUM*) NUTS

Many *kamani* nuts were gathered, from very ripe with shriveled outer shell to barely ripe with smooth green shell. The kernels inside were invariably round, white, and plump. Removing any appreciable oil from freshly gathered nuts was not possible. Nuts roasted and pressed released a watery green liquid which when exposed to air became very sticky, not oily. Other nuts were placed in the oven to speed aging and increase oil-cell breakdown, and still others were immersed in an organic solvent (toluene) to dissolve the gummy exudate. None of these methods produced oil.

Kamani nuts that had been removed from their outer shells a year previous were pressed. These nuts had shriveled slightly and turned light brown. From these an oil-like substance could be pressed out. This was the oil used in testing.

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