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Oil on Paper: A Collaborative Conservation Challenge

ABSTRACT

The application of oil-based leather dressing, once considered a best practice in libraries, led to undesirable long-term consequences for bound materials. At the National Institutes of Health in the National Library of Medicine, many leather-bound volumes had multiple applications of a mixture of neat's-foot oil and lanolin dressings applied liberally. The oils not only absorbed into the leather bindings but also migrated onto the pastedowns, end sheets, gutters, and text blocks. The oiling process at the National Library of Medicine was documented by call number, year(s), number of applications, and dressing formula. While investigating treatment options, National Library of Medicine book conservator Holly Herro consulted paintings and objects conservator Scott Nolley for insight on viable options for the removal of oil from artifacts. An art-on-paper conservator, Wendy Cowan, joined the collaborative effort to develop a treatment protocol for the National Library of Medicine's oil-saturated collections. Together, they investigated the issue and devised an effective method for removal of this oil from the National Institutes of Health collection materials. The protocol involves washing with an alkaline solution, followed by alternating applications of petroleum ether and acetone applied either over suction or by immersion. Oil components are solubilized by the alternating polarities of the solvents and then removed from the paper using suction or immersion. After the oil is removed, the paper is washed again with alkaline water to remove any remaining water-soluble discoloration. This paper will explore further details of the treatment protocol, its development and applications, and the benefits of cross-disciplinary collaboration.

INTRODUCTION

The application of oil-based leather dressing resulted in condition problems for many library materials in the National Institutes of Health (NIH), National Library of Medicine (NLM), History of Medicine Division (HMD) collection. Problems include weakened binding structures; spue/bloom; and, most noticeably, oil-saturated paper. The oil is concentrated on the end sheets, pastedowns, and gutters, causing embrittlement and discoloration. Although the oil does not appear to be actively migrating further into the text blocks, the weakened, brittle, and discolored substrates are a concern for both the conservation and curatorial staff.

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A NOTE ON TERMS AND PROCESSES

Oiling, *oiling-off*, and *dressing* are terms used by bookbinders to refer to the process of applying a mixture of fats, oils, waxes, and other substances to animal skin bindings. To maintain continuity in this paper, the term *dressing* will be used to reference the procedure and *leather* to generally reference animal skin bindings.[1] These dressings, which varied in composition, were believed to "prevent or retard deterioration, preserve, and, to a limited extent, restore flexibility to leather" (Roberts and Etherington 1982, 154). In some cases, potassium lactate was also applied as part of the dressing procedure. Leather dressing application was widespread among both individuals and institutions for decades. In many cases, the procedure provided an immediately satisfying tactile and visual improvement in the condition of the bindings, along with a sense of having "done something" for the books (National Park Service 1993), an effect that likely delayed cessation of the practice once evidence of dressing-related damages began to appear. This evidence did eventually result in the discontinuation of accepted use and the relegation of the practice to the category of damaging former treatments.

A BRIEF REVIEW OF THE HISTORY OF THE PRACTICE OF LEATHER DRESSING

Tanneries have long been adding fats during the manufacturing of leather, but the earliest use of dressing on leather bindings is not widely documented. One hypothesis, published by McCrady (1990) in the *Abbey Newsletter*, states the widespread use of leather dressing on other common leather materials, such as shoes, harnesses, saddles, and other tack led to the eventual use on leather books. With the advent of the Industrial Revolution, there was an increase in indoor air pollution, and this, combined with the addition of sulfuric acid to the tanning and dyeing processes, led to increased leather deterioration commonly referred to as red rot. Atmospheric sources of sulfur dioxide were documented beginning as early as 1850 (Haines 1977, 59), and this led book owners to turn to the primary technique employed in protecting other leather products: the application of leather dressing (McCrady 1990). Leather dressing was undertaken both on bindings in pristine condition and, typically in conjunction with consolidation techniques, on bindings already affected by red rot.

The process of applying leather dressing and numerous bookbinding dressing formulas are well documented. Pamphlets, books, brochures, and videos are available with instruction on selecting and/or mixing and applying dressing to bound materials. Most dressing formulas contain oils, fats, and waxes in addition to various other additives. The most common component is lanolin, a translucent, yellowish-white wax extracted from raw wool. It is useful for its emulsifying properties, penetrating power, and shelf life. Neat's-foot oil, a pale yellow fatty oil made by boiling the feet (excluding hooves), skin, and shinbones from cattle, is a frequent companion to the lanolin. Either beeswax or a vegetable wax, slightly harder than lanolin, was sometimes added to boost the body of the dressing. Some of the most commonly referenced dressings also contain cedarwood oil as a thinner for control of consistency and primarily for its fungicidal effects (AIC Wiki 2009).

The earliest household leather dressing formula located by McCrady (1990) is a 1795 recipe intended for shoes and advertised for "making leather impervious by water." This and several other early recipes included common components of some of the later bookbinding dressings. However, it was petroleum jelly—a waxy hydrocarbon marketed under the then recently patented brand name Vaseline—that made an appearance by 1890 as one of the earliest recommended leather bookbinding dressings.

The Worcester County Law Library began using petroleum jelly on law books around 1910. In 1933, the U.S. Department of Agriculture (USDA) published a leaflet encouraging the use of leather dressings to "add many years to the service of a leather binding" through protecting the fibers and sealing them against atmospheric pollutants. The leaflet directs book owners to apply dressing to bindings when new and to repeat the process every year or two. The reasoning behind the repeat application was that lapses in dressing application would allow for more absorption of pollutants and ultimately resulted in decay that could not be repaired with further applications, although it could be slowed. The USDA leaflet encouraged both the use of a purified petroleum jelly and a 60:40 neat's-foot/lanolin mixture that was developed by the New York Public Library (Frey and Vetch 1933).

Two of the more widely referenced dressing formulas are the British Museum leather dressing and the New York Public Library formula described earlier. The British Museum leather dressing was primarily lanolin with the addition of cedar oil, beeswax, and a solvent—most commonly hexane. Some formulas, such as one from the Central Research Laboratory, were tailored to the fat content of the leather but commonly included a combination of lanolin, neat's-foot oil, and either TERIC N9 (a surfactant) or Shellsol T (a hydrocarbon solvent). Common materials found in other dressing recipes included sodium stearate, water, castor oil, and sperm oil. Often, leather dressings were preceded by the application of a 7% potassium lactate solution (Plenderleith 1946, 18-22). The USDA leaflet provided seven different choices for leather dressing ranging from off-the-shelf products to recipes for mixtures (Frey 1933). In a 1956 update, Rogers and Beebe (1956) added commercially available saddle soap to this list of options.

Plenderleith (1946) confirmed the USDA reasoning behind dressing leather, stating that the goal of the dressing was to provide "a lubricant for the fibrous tissue, preventing it from drying up and cracking." This was commonly referred to as "feeding" the skin. Both this and the 1933 USDA publication address red rot, but Plenderleith determined that the powdery substance was not a result of the leather "drying up" and states that neither the application of potassium lactate nor leather dressing prevents or treats red rot. He presents an examination of the sulfuric acid absorption process in leather and notes that degradation continues with or without the application of dressing. Despite this, Plenderleith encourages the use of dressing to combat wear and tear:

> When chemical deterioration has once set in, it cannot be cured or even satisfactorily arrested by belated treatment with lactate. In such cases the best course is to apply the British Museum Leather Dressing, which will soften the tissue and prevent the powdery surface from spreading. (Plenderleith 1946, 22)

Consolidation of red rot was initially attempted via the application of lacquers. First, the books were dressed, then a day or two later, a spray or brushed coat of cellulose nitrate-based coating would be applied. Although it was known that leather dressing would not consolidate the deteriorated leather, the dressing could not be applied over the impervious lacquer used for this purpose, so powdery books were rubbed as smooth as possible, dressed, and lacquered (Frey 1933, 6). The 1956 updated USDA publication concurred with Plenderleith's assessment of the reasoning behind dressing deteriorated leather (Rogers and Beebe 1956), and subsequently many other institutions followed suit. However, Plenderleith's aim in addressing red rot in 1946 did not have the intention of treating it but rather to encourage binders to use skins that passed the Printing Industries Research

Association (PIRA) test for leather. It was his claim that this leather contained a "protective ingredient" that would limit the degradation due to atmospheric sulfuric acid (Plenderleith 1946, 24). Dressing applications were encouraged as a means to replace absent oils or greases in the bindings whether or not the leather had passed the PIRA test.

Despite the prevalence of dressing leather, guidelines printed in leaflets on the subject varied greatly regarding application methods, frequency, formulas, and selection of materials. There was general agreement that leather deterioration happened due to acidity, but some speculated that it might also be affected by a lack of certain materials, be they nontans, salts, or grease. Most agreed that dressing leather did not stop deterioration. Only some advocated for the application of potassium lactate first, with a large range in recommended drying times. Dressing application methods ranged from "apply small quantities by hand using a cotton swab" (Rogers and Beebe 1956) to "the oil should be applied quite liberally with a paint brush" (Banks 1967). Recommendations regarding dressing books affected by red rot also varied. Some leaflets note that powdery leather absorbs more dressing, whereas others state that dressing these books is ineffective but "does no harm," and another recommended dressing "all leather books, even the powdery ones." Most institutional leaflets did provide some guidance regarding protecting the text block or taking care with nonleather portions of the volumes. As for frequency, some direct the user to repeat the process yearly, some every two to five years, and some only "if dry looking." As an additional measure, to encourage dressing absorption, books were sometimes placed in 100°F to 115°F locations for several hours (Frey and Vetch 1933).

One treatment procedure for dressing a leather volume is as follows (Plenderleith 1946, 20):

> Scrub dirty binding with soap and water
> Open book, allow to remain for a day standing on end to dry
> Carefully sponge dry book with 7% Potassium Lactate solution
> After 24 hours, rub a little of the British Museum Leather Dressing on the surface
> After 2 days, polish binding and return book to shelf.

Environmental controls are emphasized in most of the leaflets as a preferred preservation method, with temperature and humidity as the focus. In 1975, the Library of Congress recommended set points of 60°F to 68°F and 55% to 65% RH, aiming to maintain a high enough humidity so that the leather would not dry out. References to nonleather skins are also present in the leaflets, but again, recommended actions vary. Some limit guidelines to restricting the use of potassium lactate on these skins. Others also restrict the use of dressing on them but encourage the use of soaps. On the conservative end, staff at the USDA in 1956 state that "valuable leather bindings that are not in frequent use may be wrapped in some well-washed fabric or stored in tight boxes." A chart of available leaflet comparisons is available in the *Abbey Newsletter* (McCrady 1981a, 25).

By the 1970s, dressing leather had become a standard institutional practice in many libraries. The mind-set by this time appeared to be focused on using the dressing as a cleaning mechanism rather than a preservation method. However, despite widespread implementation, the process was not always carried out by fully trained staff. At the Library of Congress, dressing was a component of the Phased Conservation program from 1971 to 1980. According to Waters (1998) at the time of his arrival to the Library of Congress in 1971, one staff member was assigned to dressing volumes, and this task was generally performed "without adequate supervision or adherence to treatment standards." Likewise, Etherington (1983) emphasizes that the person performing the dressing was often poorly paid or a volunteer and "invariably housed in the basement or attic or hidden somewhere in the stacks." Additionally in 1971, dressing was a regular part of collection maintenance at the Newberry Library, where the library's plan included "individual repair work as needed, proper storage, dusting and, in the case of leather bindings, periodic oiling" (Towner 1933, 155). In the latter case, the dressing was intended to lubricate the fiber bundles and thus reduce the need for dusting.

The practice of dressing leather continued to be widespread in institutions through the 1980s. For example, there are records of regular applications of dressing at the NLM during this time. The Pierpont Morgan Library completed a major leather dressing project in 1984. The Library of Congress was researching the effectiveness of different leather dressing formulas but routinely using the NYPL formula thickened with carnauba wax. However, by this point, anecdotal evidence alluding to potential problems had started to surface, and the benefits of the practice were under examination. It was also during this time that the application of hydroxypropylcellulose (Klucel G) as a consolidant prior to dressing was introduced by Anthony Cains (Evetts 1984). McCrady sums up decades of institutionalized leather dressing: "The dressing of leather bindings is a popular and well-established procedure, yet there is a fair amount of experimental evidence that it has little or no effect on leather's rate of deterioration. Whether the costs of a dressing program are justified by its benefits is a matter for each library to decide." (McCrady 1981b, 25).

Ultimately, most libraries discontinued their leather dressing programs, although the reasoning behind these conclusions was not purely a cost-benefit analysis but rather due to the combination of a lack of clear benefit and a growing body of evidence pointing to dressing-related damages.[2] Some of these damages were presumed to be the result of unsupervised application by untrained individuals as described earlier (McCrady 1990). Overzealous or cavalier application led to oil migrating into the text block, causing staining and embrittlement (Brewer 2006). Overdressed bindings were sometimes sticky or discolored due to the quantity of dressing applied (Hadgraft 1989). Spue appeared on many previously dressed leathers, most often those known to be treated with both a neat's-foot oil/lanolin dressing and potassium lactate (Gottlieb 1982; DePhillips and Mader 1997). In some cases, mold appeared (McCrady 2001). Spine and sewing damage resulted from the application of dressing to thin, poor-quality leather on many mass-produced bindings (Conn 2005). Metal furniture exhibited corrosion due to its proximity to oily leather (AIC Wiki 2011).

As documentation of damage increased and evidence for the benefits of leather dressing failed to surface, the application of leather dressing declined as an institutional practice. By the late 1990s, even those preservation publications that did provide instructions for the application of dressing typically did so with caveats (Heritage Collections Council 1998, 54). By 2000, the practice of using leather dressings on original bindings had declined noticeably (St. John 2000).

Current institutional policies trend toward minimal intervention for deteriorating leather. Ensuring adequate housing and polyester dust jackets for books displaying red rot are common recommendations for the general public (Library of Congress 2017). Leather dressing is no longer a widely practiced conservation treatment on original bindings, and when red rot consolidation efforts are undertaken in the conservation laboratory, they instead typically involve some combination of ethanol-based applications of hydroxypropylcellulose (Klucel-G); an acrylic polymer such as SC 6000; or a combination of the two, known as the CCAHA Red Rot Cocktail or Cellugel (Hain and Straw 2011). There are both ongoing and published studies evaluating the effectiveness of these and other materials for red rot consolidation. As is the case with many former treatments, however, the private collector continues to have access to nonconservation resources touting the wonders of leather dressing, including online video instruction for applying a variety of available off-the-shelf formulas.

NLM CASE STUDY

FORMER USE OF LEATHER DRESSING AT THE NLM

Leather dressing was routinely applied to bound materials at the NLM in the 1970s and 1980s. The formula used was a 60:40 mixture of neat's-foot oil and lanolin. Records indicate that most animal skin bindings were dressed twice: once in the 1970s and once in the 1980s. Dressing was applied by a full-time library professional who dedicated half of her time to conservation and preservation activities, but at the time, the NLM did not have a conservation laboratory. Dressing was applied primarily to leather but was also applied to parchment and vellum covers in some cases. Thorough dressing migration into the end sheets, pastedowns, and gutters is present in some bindings (fig. 1). Page edges are also sometimes affected, presumably as the result of liberal dressing application. Evidence of previous dressing migration can also be found on materials later rebound in buckram library bindings. It is unknown whether these volumes were dressed at the NLM or elsewhere, but based on other provenance, the former seems most likely. In addition to the migration of oil into the paper, spue was documented in sections of the collection.

PREVIOUS RESEARCH ON THE REMOVAL OF LEATHER DRESSING FROM PAPER

The search for an oil removal method was initially requested for aesthetic purposes by a curatorial staff member. Conservation staff assessed the situation, and although many of the affected pages are modern end sheets, others are historic and the presence of oil could pose a long-term structural problem. Verbal consultations with other conservators and a literature search revealed that similar oil migration is present at other institutions, and several studies exist on the removal of oil from paper. Some previous studies reduced the oil, although none fully removed all of the neat's-foot/lanolin dressing components from the substrate. The prior studies contain excellent information and should be considered by conservators approaching similar treatments, but early attempts by the NLM conservation staff to test oil removal using known methods were not successful in this situation.

As explained in the work of Stockman (2007), oils can be nondrying, semidrying, or drying. Higher numbers of double-bonded carbons correlate to a higher degree of drying. The number of double bonds can be determined by the amount of iodine that will react with the oil. The iodine number, in most instances, can be correlated to the color of the oil. A darker-colored oil generally has a higher iodine number and more double bonds and is more drying than a lighter-colored

Fig. 1. Example of an oil-saturated end sheet in the NLM collection. Photograph by Scott Nolley.

oil. One of Stockman's tests indicated that two or more solvents in succession applied via pipet over suction solubilized different components of a linseed oil stain, which has a high iodine number. Solvents applied were toluene, methanol, pyridine, tetrahydrofuran, and methyl ethyl ketone.

Lower iodine numbers/fewer double bonds typically result in oils that are easier to reduce. The leather dressing examined for the NLM study is a mixture of oil types with neat's-foot oil having an iodine number between 69 and 76 and lanolin having an iodine number between 15 and 49, thus putting the mixture between semidrying and nondrying (CAMEO 2016a, 2016b). Oils typically have both lipophilic and hydrophilic components. Neat's-foot oil is a mixture of various fatty acids that are approximately 67% oleic and 17% palmitic, with the remaining 16% consisting of other components. Lanolin is a mixture of high molecular weight alcohols and fatty acids.

Campbell (2009) individually evaluated the effectiveness of aqueous treatments, hexanes, isopropanol, acetone, and lipase for the removal of three different neat's-foot/lanolin-based dressing formulas from paper. The study focused on both historic and modern papers that underwent accelerated aging after the dressing was applied directly to the paper. Although several of the tests were partially effective at removing dressing components, none was fully effective at removing the waxy components present in some dressings. Campbell's study also examines the effects of the selected solvents on printing inks, which is imperative to consider if embarking on a dressing removal treatment that has affected media.

While investigating the potential treatment options, NLM book conservator Holly Herro consulted Scott Nolley, chief conservator at Fine Art Conservation of Virginia, based in Richmond. Given the prevalence of lacquers and other coatings on paintings, Herro thought that Nolley might have some insight into methods for removing the oil. Although Nolley did not have an immediate solution, he was intrigued by the problem of oil embedded in paper and requested a sample for testing.

DEVELOPMENT OF A TREATMENT PROTOCOL

A modern, but naturally aged, oil saturated end sheet from a 15th century book, *Practica, seu Lilium medicinae*, was selected from the NLM collection (Bernard 1496). The book had been rebound in the 1940s, and the blank, modern, unsympathetic end sheet was approved for testing, removed from the volume, and sent to Nolley for experimentation. The paper is 6 mils thick and laid. This sheet was divided into eight numbered strips to be used for testing (fig. 2).

Acting on the premise of the like-dissolves-like and using the steps described later, the following treatment protocol was explored for the NLM case study. The treatment protocol uses a similar concept to both the Stockman and Campbell studies for solubilizing the oil components but differs in that it incorporates the combined effect of pre- and postaqueous treatments with the effective use of alternating polarity solvents using suction or immersion.

Fig. 2. End sheet cut into test strips for experimentation. Photograph by Scott Nolley.

The overall rationale for testing was to determine if some solvent systems used typically in paintings and objects conservation to affect oil residues could be used successfully to move oil out of paper. Nolley started testing solutions for oil mobilization by locally swabbing the samples and allowing the solution to wick into a thickness of cotton blotter situated below the sample (fig. 3). Unsightly tide lines appeared in the substrate, and for help resolving this, Nolley consulted local art-on-paper conservator Wendy Cowan of Richmond Conservators of Works on Paper. They concluded that while the swab application of a combination of polar and nonpolar solvents was moving oil laterally through the paper substrate, it was not being pulled out. For effective oil reduction, the samples either needed to be immersed in a solvent bath or the treatment performed using a suction device.

Based on Nolley's experience with semidrying and nondrying oils, and after considering the known properties of the 60:40 neat's-foot oil/lanolin combination, a range of options

Fig. 3. Swab application of solvent. Photograph by Scott Nolley.

from immersion and swab treatments with aqueous and nonaqueous polar and nonpolar solvents, bleaching, and nonionic surfactants were tested. The degree of oil removal was qualitatively assessed using long-wave UV light. Residual oil fluoresces under UV light, indicating that removal is not complete (fig. 4).

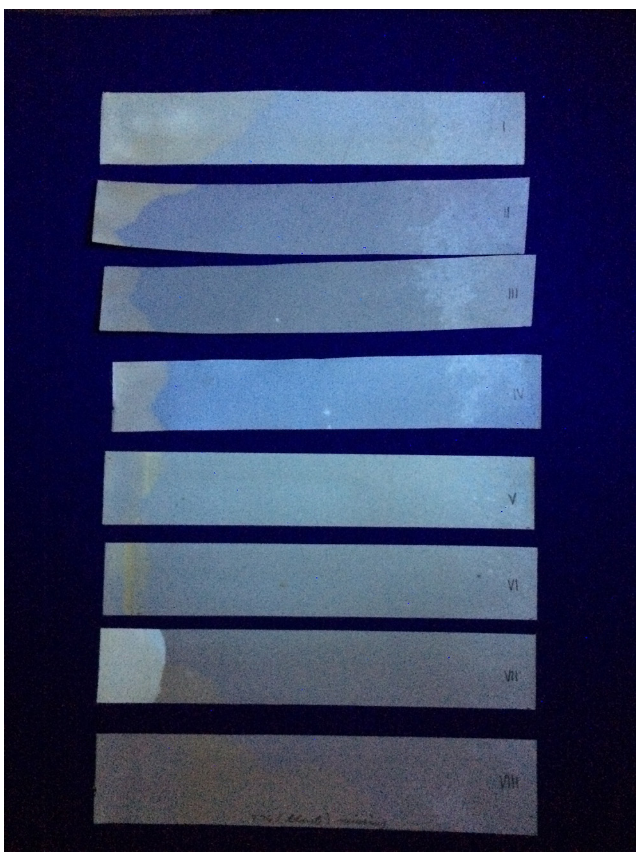

Fig. 4. Effectiveness of oil removal can be evaluated using long-wave UV light. Photograph by Scott Nolley.

In the first stage of testing, the following solvent combinations were tested on the numbered samples; sample I was the control in this experiment, and all ratios are volume to volume:

I. Control
II. Immersion in deionized water buffered to pH 9.0 with ammonium hydroxide
III. Immersion in 1:1 deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide
IV. Immersion in 1:1 deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide, then immersed in a 3% hydrogen peroxide and water solution followed by two baths with calcium carbonate
V. Swab application of 1:1 acetone:ethanol
VI. Swab application of 1:1 acetone:toluene
VII. Swab application of aqueous nonionic surfactant system with 2% ethylenediaminetetraacetic acid (EDTA)
VIII. Swab application of 20:20:40:20 mixture of acetone, diacetone alcohol, naphtha, and methanol (Acetone Mixture IV).

These initial results led to a second testing stage that involved dividing each strip in half and renumbering ii.a, ii.b, iii.a, iii.b, and so forth. The treatment protocols were reversed on one of these half-strips for each sample. Samples ii.b, iii.b, and iv.b, which had been washed in the first stage, were treated with solvents in this stage. Samples v.b, vi.b, vii.b, and viii.b, which were tested with solvents in the first stage, were immersed in the aqueous cleaning solutions in this stage (fig. 5).

The results in normal illumination indicated that the nonaqueous solvents—acetone and petroleum ether—were most effective in mobilizing oil, and thus these were the solvents chosen for samples ii.b through iv.b in the second stage of testing. Samples v.b through viii.b were immersed in a 1:1 deionized water and ethanol bath raised to pH 9.0 with ammonium hydroxide. The selected treatments for stage 2 were based on observations on the most effective methods in stage one (fig. 6).

The effectiveness of the combined treatment is evident in the comparison of samples ii.b and iii.b. Of these, iii.b exhibited a greater degree of oil reduction than ii.b. The difference in methodology for these two samples was the addition of ethanol to the initial bath for sample III. Samples v.b through viii.b, which were swabbed with solvents in stage one and immersed in stage two, did not display ideal results. Although the surfactant system applied in sample vii successfully removed the oil, the surfactant was not effectively removed from the paper. It is the combination of the initial washing treatment and the subsequent application of the alternating polarity solvents via either immersion or suction table treatment that is necessary to remove the tide lines and discoloration from the paper.

Fig. 5. Samples in normal light after first stage of testing. Photograph by Scott Nolley.

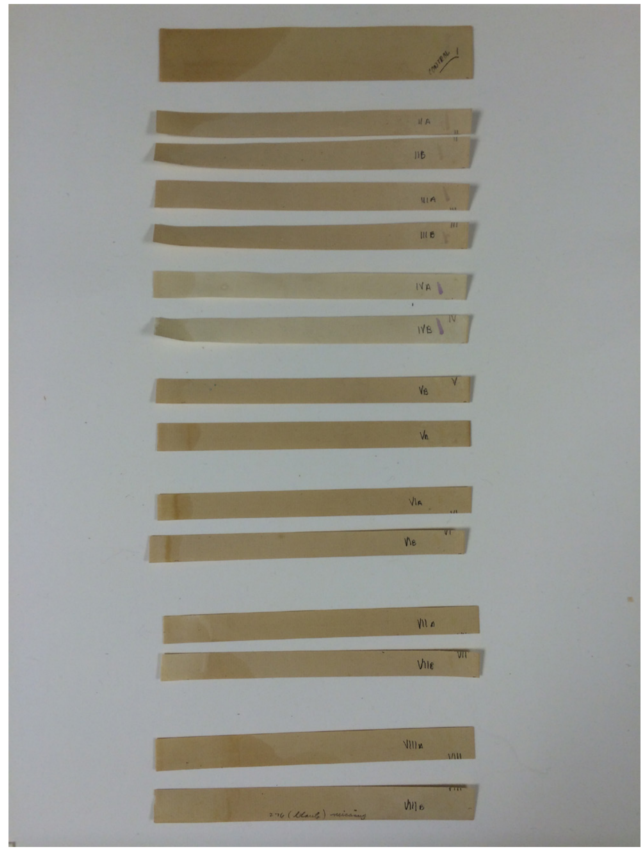

Fig. 6. Second stage of testing reversed the first-stage treatment protocol. Photograph by Scott Nolley.

The treatment protocol for the NLM case study was as follows. After spot-testing any media, prewash the affected page in a 1:1 solution of deionized water and ethanol buffered to pH 9.0 with ammonium hydroxide. In these tests, the samples were washed in three baths totaling one hour and air-dried. Applying solvents with a pipet over suction or using immersion, first use petroleum ether, a low-polarity solvent that solubilizes the lanolin. Then use acetone, a high-polarity solvent, to solubilize the neat's-foot oil. Continue alternating these solvents at a 1:1 ratio, changing the blotters regularly if using suction, until the oil is visibly reduced. To evaluate the oil removal treatment, periodically view the substrate using a long-wave UV light and look for any fluorescence of remaining oil. After the oil is reduced, wash the paper in a deionized water buffered to pH 9.0 with ammonium hydroxide.

TREATMENT REPLICATION

The NLM conservators proceeded to replicate this treatment process on several additional oil-saturated leaves. The first page tested was the corresponding end sheet to the one used for the development of the treatment protocol. This treatment was performed as an in situ spot treatment on the suction table. The oil was successfully reduced in both visible and UV light after approximately nine alternating applications of the solvents (fig. 7).

The second sample chosen was also a nonhistoric oil-saturated end sheet. The end sheet was removed for testing. It was 9-mil-thick laid paper that is heavily sized as determined by a water droplet test. After more than 40 applications of each solvent, some of the oil appeared to be reduced in visible light, but staining continued to be present in visible light and substantial fluorescence remained under UV light. Most of the observed oil reduction occurred in the first nine suction table solvent applications. A second sample from this leaf was immersed in alternating baths of petroleum ether and acetone with similar results. The authors hypothesize that the remaining oil in this substrate is attributed to the sizing and fillers in the paper, which interfere with the oil reduction and possibly contribute to the continued fluorescence under UV.

The third leather dressing-saturated paper tested was the first historic sample selected for treatment—a detached, blank end sheet from a late 18th century book. The end sheet was treated on the suction table using the developed treatment protocol. The paper was 7 mils thick, wove, and lightly sized as determined by a water droplet test. Nine applications

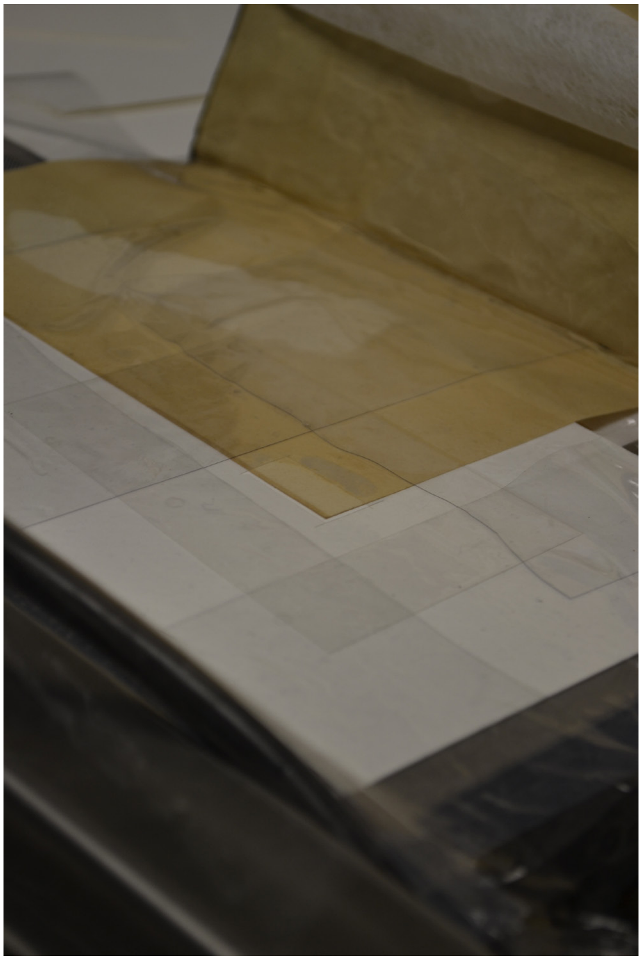

Fig. 7. Suction table application of solvents is a possibility for in situ treatment. Photograph by NLM staff.

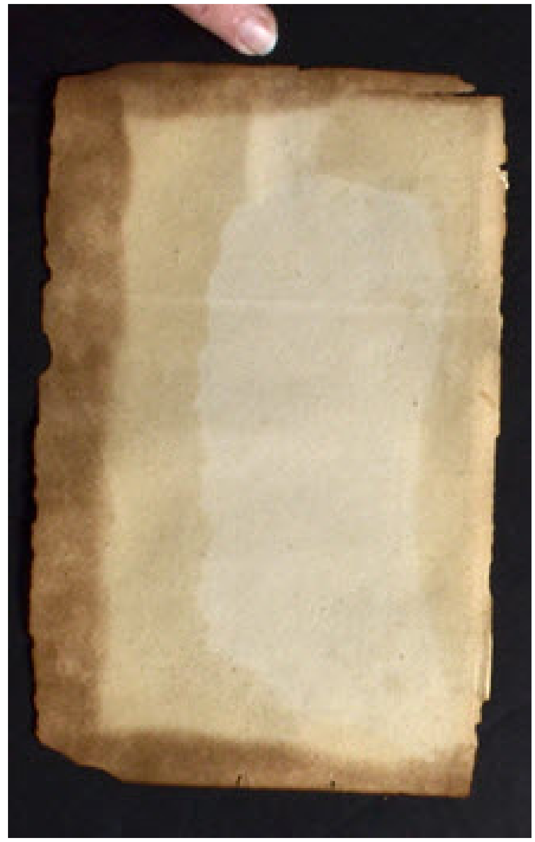

Fig. 8. During-treatment photograph of historic end sheet with oil partially removed. Photograph by NLM staff.

of each solvent using suction reduced the oil in both visible light and UV light (fig. 8).

During the course of this study, a manuscript saturated with motor oil was brought to the NLM conservation laboratory for treatment. The oil had considerably darkened the 4-mil wove, well-sized substrate. The paper was brittle and fragmenting throughout. Although motor oil is a petroleum-based nondrying oil, the authors chose to test the treatment protocol on an already separated ¼ in. blank fragment. The oil was successfully reduced using nine alternating applications of each solvent using suction.

OBSERVATIONS AND RECOMMENDATIONS FOR FURTHER STUDY

The end sheets tested to date have not contained media and, as with any solvent treatment, spot-testing must always be undertaken when treating any object. The pre- and post-treatment baths prevent tide lines and remove any residual water-soluble discoloration, respectively. This combination of prewashing the samples to prevent tide lines and mobilizing the oil-based leather dressing using alternating polar and nonpolar solvents emerged as the most effective treatment protocol. Although the treatment methodology discussed here is effective at solubilizing the specific 60:40 neat's-foot oil/lanolin dressing mixture present on the NLM materials, further research needs to be done on reducing oil migration from other leather dressing formulas.

Additional testing of this treatment protocol on nondressing oils, such as motor oil, could also be beneficial. It is the authors' observation that it is necessary to consider some aspects of the composition of the paper when considering this treatment option. With the known dressing mixtures, investigation into how fillers, sizing, and coatings found in substrates affect the results and aging studies to determine the long-term effects of the treatment on the substrate is necessary. For all of the aforementioned research needs, quantitative analysis to further examine the results will be considered for future testing.

This cross-disciplinary collaboration was a great experience for the project team that resulted in a new treatment protocol to consider for removing the specific leather dressing found on the NLM collection. Of course, no treatment can be used universally due to the many factors to consider for each collection item. This project gave the NLM book and manuscript conservators the opportunity to explore treatment options from conservators in other disciplines and resulted in a successful method for reducing the oil in text blocks damaged from leather dressing application. The project team hopes that this case study will encourage other conservators to seek the valuable advice and guidance from colleagues both within and outside their respective disciplines when faced with a difficult treatment.

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NOTES

1. It should, however, be noted that dressings were sometimes applied indiscriminately to tanned, tawed, and parchment skins. In the authors' observation, in some instances dressing was even applied to cloth or paper bindings, presumably due to misidentification.
2. Oil-damaged paper is not always a result of the application of leather dressing. Some tracing papers were intentionally impregnated with oils to render them transparent (Bachmann 1983). Oily stains in paper can have many sources, such as cooking oil or motor oil. On bound materials, leather burn, particularly common on turn-ins, is not a result of dressing application but rather oils added during the tanning process (Conroy 1991). Although leather burn could presumably be exacerbated by leather dressing, many procedures did not recommend the application of dressing to turn-ins.

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