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Heat-Set Tissue: Finding a Practical Solution of Adhesives

From 1997–2014, Kathy Ludwig served as senior conservator and liaison to the Textual Unit at the National Archives & Records Administration. In addition to many other contributions to the field of conservation and the agency, Kathy initiated this research project in 2013. She researched the replacement resins and conducted the aging, reversibility and blocking studies. She also perfected the technique of making heat-set tissue before retiring in July 2014. Kathy passed away in May 2015. This paper is dedicated to her memory as a gifted conservator and kind friend.

INTRODUCTION

For years the Document Conservation Laboratory at the National Archives & Records Administration has been using heat-set tissue as one of the methods to mend documents. Heat-set tissue consists of a low-viscosity acrylic emulsion polymer applied to various weights of mending tissue. The adhesive is reactivated using either heat or solvent during application, although both applications will be referred to as heat-set tissue in this paper. It can be used to mend tears, fill losses and line documents. It is a preferred method for mending certain types of documents due to its transparency, low sheen, reversibility, consistency among users, ease and speed of application and it does not require moisture. Heat-set tissue is used in other contexts such as mending tracing papers or other similar thin papers. It is preferred when treating mold damaged records to avoid introducing moisture to vulnerable substrates.

The National Archives & Records Administration has approximately 12 billion textual documents in its holdings. The use of heat-set tissue has increased as more of the holdings are scheduled to be digitized. In 2014, approximately 11,000 records came into the Document Conservation Lab for treatment prior to scanning. 65% of these records required mending for stabilization to permit safe handling at the camera and assure legibility of text. (fig. 1) The number of documents needing treatment may fluctuate year to year depending on the project or condition of the records. Thus mending must be quick without compromising neatness or the proper alignment of text. Often the documents have text on both sides. Conservators mend directly over printed and

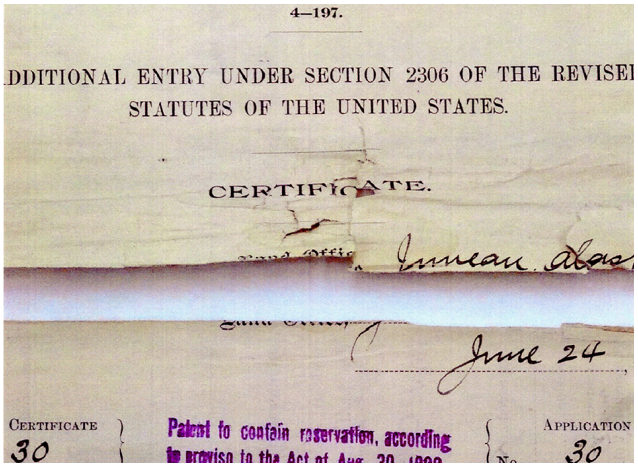

Fig. 1. Example of torn textual document.

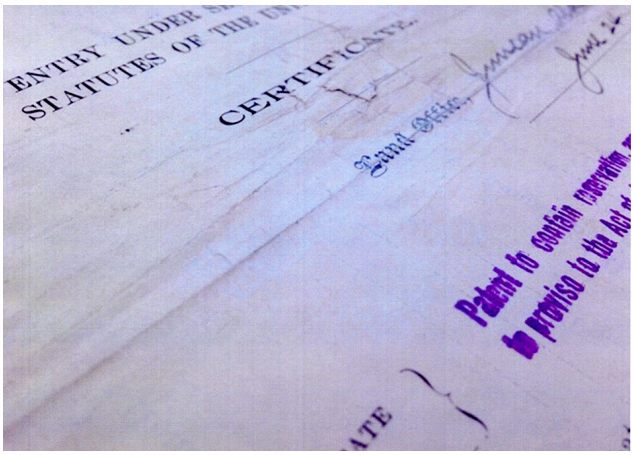

Fig. 2. Example of heat-set tissue mend applied over text.

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written ink. (fig. 2) For digital prep, the documents are rarely washed and minor tears or losses are not repaired. In addition to heat-set tissue, gelatin remoistenable tissue and wheat starch paste and Japanese paper mends are used for mending.

EVOLUTION OF THE RECIPE

In the past, conservators at the National Archives & Records Administration used a heat-set tissue recipe that was first developed by colleagues at the Library of Congress in the 1970s. The recipe itself has evolved over time due to the marketplace discontinuation of the acrylic emulsions. Thus, conservators have been forced to explore the use of other available resources.

Over the past several years, we have worked to find a replacement resin with acceptable working properties, adhesion, and appearance that also meet the conservation requirements of the National Archives & Records Administration. This was a collaborative effort between conservation and conservation science staff. Many factors were evaluated including various combinations of adhesives and methods of adhesive application on different types and weights of paper.

Prior to settling on the current recipe, the National Archives & Records Administration had used two other recipes over the years. All three contain three components—water, a flexible but tacky resin and a brittle resin. The brittle resin is added to make the mixture less tacky to avoid blocking. The first recipe from the 1970s combined Rhoplex™ AC-73 with Plextol® B 500. However, Plextol® B 500 became difficult to purchase. Eventually Plextol® B 500 was replaced with Rhoplex™ AC-234. Meanwhile the Rhoplex™ AC-73 remained part of the mixture. This recipe was used for decades until both manufacture of Rhoplex™ AC-234 and Rhoplex™ AC-73 was discontinued. By 2012 NARA could no longer order these products. National Archives & Records Administration's Senior Conservator Kathy Ludwig began to search for an alternative.

FINDING REPLACEMENT RESINS

Two alternatives were compared to the original recipe. One mixture combined Plextol® B 500 and Avanse™ MV-100 while the other combined Rhoplex™ ML 200 with the Avanse™ MV-100. The two trial mixtures were cast onto sheets of lens tissue and Kozo papers. The tissue was adhered with heat (225–250° F) onto two different expendable substrates along with strips of the original Rhoplex™ mixture.

AGING STUDIES

Aging studies were performed to observe color change, working properties and reversibility on the comparable resins. The mends created with the three recipes were placed in an aging oven using ISO aging conditions of 80° C and 65% RH for 44 days. Prior to the oven aging, the samples were photographed for color comparison and were photographed again after oven aging. The aging study was performed on photocopy paper for ease of noting color change of just the heat-set tissue. Accelerated aging experiments with reversibility studies, as well as FTIR, were run to characterize the adhesives further. The Avanse ™/Plextol® mixture aged well and looked similar to the original heat-set tissue, (fig. 3) whereas the Rhoplex™/Avanse ™ adhesive turned brown with aging. In addition, the Avanse ™/Plextol® mixture passed the Photographic Activity Test.

REVERSIBILITY STUDY

The Avanse ™/Plextol® samples were easier to remove with local applications of ethanol and acetone. The Rhoplex™/Avanse ™ samples required more physical manipulation. We looked at a commercially-available heat set tissue, as well. It is reversible after aging with ethanol and acetone but it is too opaque and can obscure textual information on documents. In addition, the commercially-available product requires constant monitoring to ensure that the adhesive formulation does not change.

BLOCKING STUDY BASED ON MIXTURE RATIO

Based on the above studies, the Avanse ™/Plextol® recipe seemed to be the best resin mixture. Avanse™ MV-100 is the brittle component while Plextol® B 500 is the flexible component. A 4:1:1 ratio is ideal. When diluted to 5 parts water, the mends do not stick. With a 3:1:1 ratio, it is difficult to remove the heat-set tissue from the silicone coated Mylar before use. Additionally, the tissue was too tacky and shiny. This caused blocking with adjacent records and materials. The heat-set tissue was adhered to expendable paper and placed under 200 lbs for 75 days. No blocking was observed. There is often a lag time between treatment and when a document is imaged and posted online by our digital partners. During this interim period when original records are still accessed, none of our mended documents have returned to the lab with blocking issues.

MAKING THE HEAT-SET TISSUE

Today the National Archives & Records Administration is currently using the recipe that includes 4 parts water, 1 part Avanse ™ MV-100 and 1 part Plextol® B 500. The resin is mixed and applied to Abaca lens tissue and two weights of Kozo (Haini) paper. Occasionally custom heat-set tissue is made with different sizes and types of papers to meet particular project needs. The goal is to produce a tissue with consistent quality and a uniform application of adhesive without creating wrinkles or holes in the thin paper.

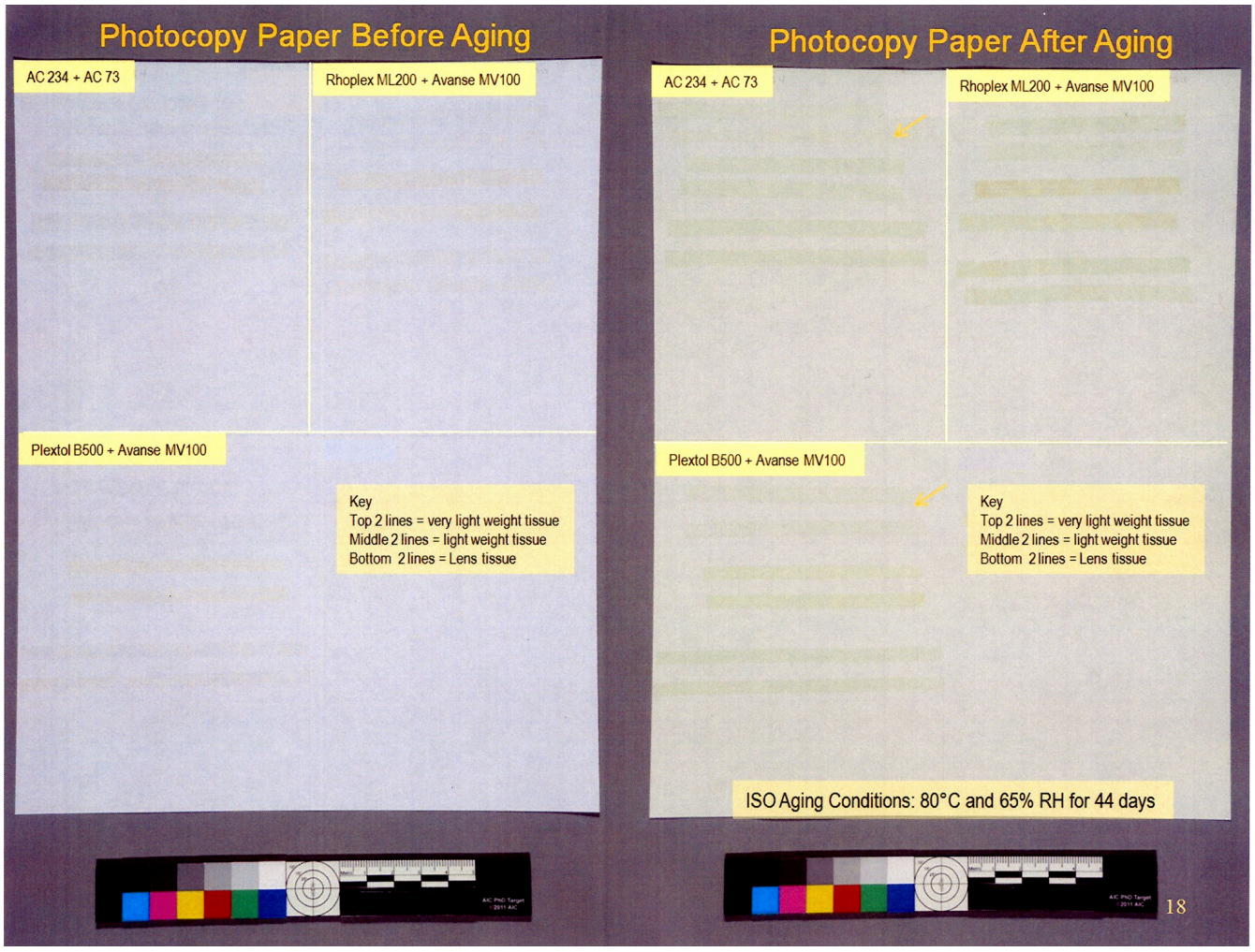

Fig. 3. Heat-set tissue mends adhered to photocopy paper before and after aging.

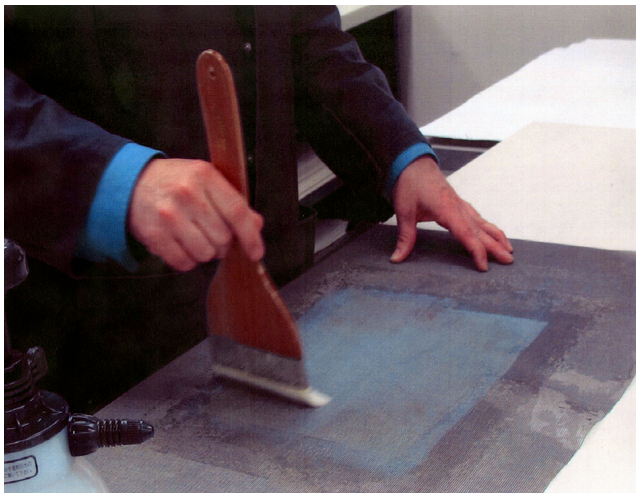

Fig. 4. Brush apply adhesive through a screen.

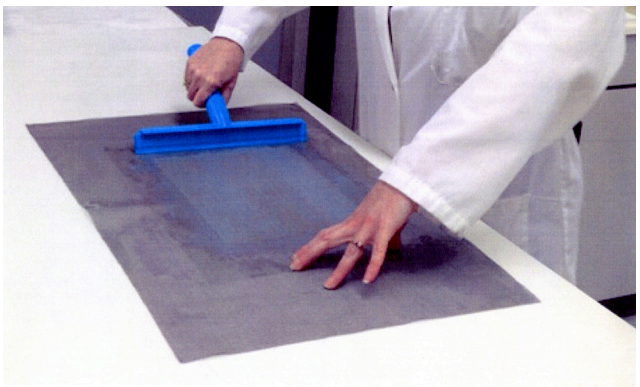

Fig. 5. After brush-applying adhesive, squeegee for even consistency.

CASTING THE RESIN MIXTURE

First a dry sheet of paper is placed on a sheet of silicone coated Mylar. A screen is placed over the paper and gently misted with deionized water to expand the fibers. It is then smoothed out with a squeegee to disperse the water. Next the resin is brushed through the screen in a union-jack pattern and squeegeed again to ensure an even consistency. (figs. 4–5) Finally the screen is peeled back and the tissue is placed on the drying rack. The tissue remains on the silicone coated Mylar during drying to keep it from distorting.

During trials, conservators experimented with brushing the adhesive onto silicone coated Mylar and dropping the Japanese paper on top. This technique keeps the adhesive on one side of the Japanese paper thereby preventing the documents from blocking or sticking to each other over time. However, it produces a higher uneven sheen than the brush-applied method. In addition, it is more difficult to peel off of the silicone coated Mylar before use.

APPLYING THE HEAT-SET TISSUE

Heat-Set

Once the heat-set tissue is dry, it can be used whole or cut into strips and shapes. It can be easily peeled off of the silicone coated Mylar after it dries or during use. Moderate temperature (250–350° F) reactivates the adhesive to adhere it to the document. The tacking iron's dwell time on the records is usually less than 15 seconds. Glassine paper or silicone release paper works well as a barrier between the document and the iron.

Solvent-Set

When the application of heat is not effective or desired, the resin can be reactivated with solvent. Ethanol is brushed onto the tissue which is resting on blotter. The tissue is then placed on the document and gently pressed with a burnishing tool. No heat or weight is needed.

Applying the solvent to the tissue while it was already in place on the document makes the document more vulnerable to tidelines. It is difficult to control the solvent and the adhesive from penetrating into the substrate. Both the heat-set and the solvent-set mends are reversible with heat and solvent.

OPTICAL BRIGHTENING AGENTS IN AVANSE™ MV-100

Avanse™ MV-100 contains optical brightening agents. The heat-set tissue fluoresces under shortwave ultraviolet illumination. After aging studies were performed, there was no noticeable migration of the fluorescence beyond the edges of the tissue. This was further tested by removing the aged tissue with a damp swab of acetone. No fluorescence was left behind on the substrate. The tissue seemed to retain the adhesive film as it could be re-adhered to the paper with a heated spatula. In the area where the tissue had been removed, conservators tried to adhere a new piece of plain, uncoated, Japanese paper. It did not adhere which denotes that there was no measurable residual adhesive left behind on the substrate. Note: the original Rhoplex™ 73/234 recipe fluoresces under shortwave ultraviolet illumination, as well.

INCONSISTENT ADHESION

The heat-set tissue works well with most papers. However, it does not always adhere well to all papers. On occasion, the tissue will stick initially and then fail after some time. After application, conservators gently flex the sheets to make sure that the mends do not pop off. There are occasions when several sheets within a batch of heat-set tissue do not adhere at all. Currently, conservators are exploring ways to avoid this in the future.

SHEEN

There is a visible sheen with the heat-set tissue made with both the original and current recipes. Some conservators are disturbed by this because the mends can be visually distracting and obvious when viewed at some angles. The sheen can be dissipated with the application of solvent. However, it adds time to the process and is only possible for papers and inks that can tolerate solvents.

CONCULSIONS

In closing, the heat-set tissue is not perfect. Despite concerns, the benefits of this method outweigh the shortcomings. In researching the adhesives we learned that chemical companies discontinue products like resins when large quantities are no longer in demand. This may occur when a large contract ends or if specifications for the product change. Discontinuation rarely occurs due to a defective product. The current recipe may continue to evolve but for now the National Archives & Records Administration plans to continue to make and use the Avanse™ /Plextol® heat-set tissue for much of the digital prep. It is the best option for a transparent, reversible tissue that is easily and quickly applied without the introduction of moisture. This is imperative when treating the volume of records that we prepare for digitization at the National Archives & Records Administration.

ACKNOWLEDGEMENTS

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APPENDIX: INSTRUCTIONS FOR MAKING & USING HEAT-SET TISSUE

ADHESIVE RESIN FORMULA

Combine and stir the following ingredients.

- 4 parts water
- 1 part Avanse™ MV-100
- 1 part Plextol© B500

CASTING THE RESIN MIXTURE

Instructions for casting the mixture onto a preferred mending tissue are below.

1. Place a dry sheet of paper on a sheet of silicone coated Mylar
2. Place a screen over the paper and gently mist with deionized water to expand the fibers.
3. Smooth with a squeegee to disperse the water.
4. Brush the resin though the screen in a union-jack pattern.
5. Smooth with a squeegee to ensure even consistency
6. Remove screen
7. Air-dry tissue on the silicone coated Mylar.
8. Store heat-set tissue in a folder to avoid dust accumulation. It can be stored on the silicone coated Mylar. Or it can be peeled off of the silicone Mylar and stored with a non-stick interleaving paper such as glassine.

GUIDELINES FOR USING HEAT-SET TISSUE

Heat-Set Instructions

Peel the heat-set tissue off the silicone coated Mylar and cut into shapes. Or cut tissue while still adhered to silicone coated Mylar.

Once cut into strips or shapes, heat-set tissue can be applied with the shiny side towards the mend using a tacking iron set to 250–350° F. Dwell time of the tacking iron should be less than 15 seconds. Use glassine or silicone-release paper as an interleaving between the tacking iron and object.

Solvent-Set Instructions

1. Peel heat-set tissue off the silicone coated Mylar and cut into shapes. Or cut tissue while still adhered to silicone coated Mylar.
2. Place heat-set tissue on blotter and apply ethanol to shiny side with a flat brush.
3. Move heat-set tissue to object with the shiny side towards the mend, apply and burnish. Weight or heat is not needed.

NOTE

This recipe meets conservation standards for use on original paper-based collection materials. Scientific analysis, accelerated aging studies with ISO aging conditions and the Photographic Activity Test were conducted. The Avanse resin contains optical brightening agents. After aging and reversibility studies, there was no noticeable migration of the fluorescing resin. The heat-set tissue works well with most papers. However, it does not always adhere well to all papers.

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