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THE TREATMENT OF TRANSPARENT PAPERS: A REVIEW

Transparency or translucence in paper depends on the comparative absence of light-reflecting or light-absorbing facets in or on the fibers. Three basic methods have been used to make paper transparent: impregnation, chemical treatment, and mechanical treatment.

Translucent papers prior to about the middle of the 19th century were made on a base of laid or wove papers rendered transparent by the application of one or several coats of oils, gums, resins, varnishes and mixtures thereof.

Architectural tracing papers as we know them made their appearance by the middle of the 19th century, after the blueprint process had been perfected in 1842. The first patent for chemically treated transparent paper was granted in 1846 in France and the process was commercially developed by the firm of Warren de la Rue in London (based on an 1857 patent by Gains).

This transparent paper, variously referred to as parchment, Pergamyn, Papyrine, and similar names, was prepared by subjecting an already-formed sheet of paper to a brief bath in sulphuric acid, followed by several washes in water, a bath of dilute ammonia, and sometimes a coating or bath of glycerine or glucose. Early parchment papers were made from rag papers; modern "vegetable parchment" papers are made on a base of sulphite pulp paper.

Another method to obtain transparency that was developed toward the end of the 19th century involved a change in the mechanical preparation of the paper fibers. The pulp for this type of paper was gelatinized by means of intensive beating -- the fibers were crushed and ground by stone beaters rather than being cut. In addition, the paper formed from this pulp was then compacted in calendering. It was not quite as transparent as the "vegetable parchment," and impregnating agents were often added to improve transparency. Oils, gums, and resins continued to be used to enhance translucency through the first quarter of the 20th century. In modern papers of this variety, the pulp base is traditionally rag for the top quality papers and sulphite pulp for lesser qualities.

The problems inherent in the materials and manufacture of transparent papers are many. The typical appearance and behavior of transparent papers of any age are often disheartening. The oil/resin impregnated papers prior to and of the 19th and 20th centuries tend to be very brittle and discolored. Their reaction to moisture, however, is not as extreme as that of the later tracing papers, which often were impregnated with oils. In these later papers the great dimensional

changes and softening in water pose a definite danger when traditional wet treatments for paper are used. The chemically treated tracing papers tend to be very acid and therefore are brittle and discolored; the mechanically prepared papers lack strength, and papers impregnated with oils or resins tend also to be brittle and discolored.

During the past year a number of different types of transparent papers were treated in the Cooper-Hewitt Museum paper conservation laboratory: oil/resin impregnated textile designs of the 18th century, architectural renderings on vegetable parchment as well as tracing papers from the turn of the century, and architectural drawings of furniture and interiors of the 20th century. The search for alternative solutions to traditional wet treatments showed that not much has been published on the subject; research is needed into the history of the manufacture and materials and uses of transparent papers. (In my short presentation at the AIC meeting in Baltimore in 1983, I touched upon some of these matters, and I intend to pursue them in a future publication.)

A review of the available literature revealed that there is a preference for the use of non-aqueous systems since the tracing papers are difficult to deal with when wet. Another consideration for choosing non-aqueous methods has been the sheer mass of materials in libraries and especially archives. Methods are needed which are efficient in time and cost. The criteria for treating transparent papers are the same as for any type of treatment: reversibility, compatibility of materials, ease of application, and the safety and integrity of the object (transparency).

This survey will deal with the reinforcement of brittle and deteriorated supports, and not techniques of mending and filling. Suffice it to say that fibermends with Japanese paper and wheat-starch paste and/or methyl cellulose are usually very successful. The tendency of the tracing papers to deform can be controlled by working on small areas; this type of mending shows very good results. Heat-set tissue as developed by the Library of Congress (acrylic resins on cellulosic fiber; Rhoplex, Rohm & Haas) also has been used; narrowly-cut strips are applied with sufficient heat to attach the mending paper, without melting the adhesive; this method makes it possible to reverse the procedure mechanically rather than with the solvent of choice, ethyl alcohol in this case.

The use of the heat-set tissue does meet the criteria mentioned, and while there is a slight change in appearance due to the density of the mending paper, it is well within acceptable limits.

The methods which have been considered for the treatment of transparent papers are: impregnation, coating, lamination, backing. The discussion of treatments follows the outline of methods of Judith Hoffenk de Graaf in Maltechnik-Restauro 3(1982). Another series of experiments is presented in Christine Steinkellner's paper in the same journal in 1979. Both authors deal with modern tracing papers only.

IMPREGNATION

Hoffenk de Graaf found impregnation not useful since the materials tested did not penetrate the dense surface of the tracing papers (this is useful in using a thermoplastic adhesive). She tested Plexisol (acrylic, Rohm & Haas) in petroleum ether, and Bedacril (methacrylate, I.C.I.) in toluene, both in differing concentrations.

Even if impregnation were possible, the aging characteristics of this system might be poor. Reversibility might be difficult and the deteriorated papers may react adversely with the acrylics and other synthetics; the question of whether such a "strengthening" would have a long-term effect is open to speculation.

COATING

For coating of transparent papers Hoffenk de Graaf experimented with E1210 (epoxy resin) and Mowilith DMC2 (PVA emulsion, Farbwerke Hoechst); again she reported no success. (Under this category I would like to mention use of methyl cellulose as reported by Catherine Asher at the 1981 AIC meeting in Philadelphia.) Methyl cellulose, when applied to the surface of "vellum," "filled" the whitish cracks, and made unrolling possible. Methyl cellulose is extremely flexible and forms strong, clear films. From the description in this paper, it may have formed a coating on the surfaces; however, the hygroscopic nature of the materials and later removal (aqueous) pose a problem.

LAMINATION

Under the category of coating, Hoffenk de Graaf included Filmoplast P (acrylic ester, Nessen) and Lamatex Coated Repair Tissue (Archival Aids).*

*J. H. Hoffenk de Graaf and C. E. M. Wolff, "Eine Methode, um Transparentpapier zu kaschieren," Maltechnik-Restauro 3(1982): 199. The authors call this a pressure sensitive adhesive. I am only familiar with Lamatex Coated Repair Tissue, which is coated with thermoplastic resin.

Both materials have pressure-sensitive adhesive on natural cellulosic carriers. (Since one adds a pressure-sensitive adhesive as well as a secondary support, I would not include the two under the heading "Coatings.") As reported, corrections and adjustments during the application of these coated papers are difficult, and the aging properties and reversibility of these films have been questioned.

The advantages of such films are that neither solvent nor heat are necessary for their application. Hoffenk de Graaf rejected the films because of difficulty of application, especially to large drawings, and because of price. Steinkellner tested Filmoplast P and reported the material and method suitable. As she described it, the film is adhered at one side of the object and the separating paper is pulled off the adhesive side as one progresses across the unlined part of the original support. This method may not be useful or safe in the case of a large or brittle paper, since the mechanical stress would be considerable.

BACKING

Proposed systems are: Aqueous, organic or synthetic adhesives
 Thermoplastic, synthetic adhesives
 Solvent-activated synthetic adhesives.

Aqueous Adhesives, Organic

- I. A 1960 publication from the USSR discussed the use of wheat-starch paste on large transparent paper after removal of the impregnating substance (oil), preceded by a consolidation of the media.

- Procedure:
1. Consolidate media two days in advance (10% solution of polyamide resins).
 2. Remove oil with a 0.4% solution of ammonia, recto and verso on a permeable support; wash surfaces on support.
 3. Paste reverse of object with wheat starch; mend, line with long-fibered paper.
 4. Stretch to dry on plexiglass.

Advantages: We are familiar with the good aging properties of the materials used; reversibility is good.

Disadvantages: Expansion in wetting and problems in flattening; some loss of transparency; drying on a rigid surface could be a problem with damaged objects. Application of adhesive to reverse of object.

Comment: The removal of impregnating agents changes the appearance -- this may be balanced by an improvement in the strength of the paper.

II. In 1980 Mary Todd Glaser (and also later in conversation, T. K. McKlintock) reported the use of starch and Japanese paper in the treatment of a large number and variety of papers from the F. Lloyd Wright archives.

Procedure: 1. Expand paper on Mylar (polyester film, Dupont), fill.
2. Apply the pasted backing (Japanese paper).
3. Blot, dry between felts.
4. Inpaint, adjust.
5. Dry in press if size permits, or on screen.

Advantages: Same as above.

Disadvantages: Same as above; expansion, flattening, tension.

Comment: Methyl cellulose can be added to the starch to make adjustments easier.

III. A 1975 publication by Otto Wächter discussed the use of PVA emulsion for backing tracing papers. In 1979 Steinkellner conducted tests using Wächter's materials and methods.

Procedure: 1. 5 parts methyl cellulose; 1 part Planatol BB (PVA emulsion).
2. Brush application of adhesive to Japanese paper; relax object on glass.
3. Apply backing to object.
4. Air dry, spray and press.

Disadvantages: Expansion and shrinkage. Poor solubility of PVA emulsion. Steinkellner rejected this method for reasons of difficulty of application and uneven thickness of the adhesive in brush application.

Synthetic Adhesives, Thermoplastic

The problem in the use of heat is that local application will expand the paper even more than in traditional laid/wove papers. An overall application of heat as in a press has a better chance of success.

- I. In 1975, in the same publication as above, Wächter also dealt with thermosetting adhesive linings.

Procedure: 1. Apply brush coat of full strength Planatol BB to new support; dry one hour.
 2. Apply original from front, cover with Pergamin (transparent paper).
 3. Iron from front, moderate heat and good pressure.
 4. If necessary repeat heat through moist blotter for better adhesion.

Advantages: Method avoids moisture.

Disadvantages: Heat, solubilities and method of application; poor adhesion; brushstrokes can show (see page 5).

- II. Steinkellner in 1979 tested three different methods for heat-activated adhesives for backings and/or lamination.

- A. Procedure: 1. Planatol BB.
 2. Proceed as above; (temperature at 80-90°C).

Disadvantages: Uneven thickness of adhesive layer applied with a brush causes blotchy appearance of paper.

- B. Method developed by the Istituto di Patologia del Libro, Rome (they laminate at 80°C and then press cold).

Procedure: 1. Paraloid B-72 (Acryloid B-72; ethylmethacrylate, Rohm & Haas) 7% or 20% solution in tetrachloroethylene.
 2. Brush application to Japanese paper, air dry.
 3. Laminating press at 100°C.

Advantages: Good aging characteristics of Paraloid B-72. At 7% solids reversible mechanically.

Disadvantages: The 7% solution did not give good over-all adhesion even at 100°C; at higher temperatures and with the 20% solution the bond was not reversible mechanically.

Comment: Tetrachloroethylene is unstable in heat (it can give off carbon monoxide and hydrogen chloride); it is an irritant and can be toxic. A solvent would be necessary to reverse the bonding with the 20% Paraloid. A lesser concentration of resin would be more desirable, as would a lower temperature.

- C. Method developed by the Austrian State Archives; lamination and backing were tested. The author preferred backing since it better preserved the original appearance of the object.

Procedure: 1. The object is placed face down on a transparent paper, followed by a sheet of polyethylene and a Japanese paper.
 2. The sandwich is tacked together here and there with a hot iron.
 3. This is covered with a separating sheet of transparent paper and placed between two cardboards.

Advantages: The polyethylene and Japanese paper can be removed mechanically.

Disadvantages: Two-sided lamination changed surface characteristics. Backing and lamination with only the plastic created shiny spots and did not give sufficient support.

Comment: The author does not discuss the aging properties of the polyethylene, a substance that is not very stable.

- III. In 1980 Thea Jirat-Wasiutynski reported the use of PVA as a thermoplastic adhesive for transparent paper; her methods are discussed under the heading Oiled/Resin Impregnated Papers.

- IV. Hoffenk de Graaf in 1982 tested PVA emulsions (50% dispersion). This method was adapted from a textile mounting technique.

- A. Procedure: 1. 1 part Mowilith DMC2, 1 part Mowilith DM5 (PVA emulsion), 4-6 parts water.
 2. Brush application to Renovapapier (viscose rayon) on Melinex (polyester sheet, I.C.I.) or Cerex (polyamide web from Monsanto).
 3. Iron through Melinex at 80-100°C onto reverse of object.

Advantages: The use of water and dimensional changes through moisture are avoided.

Disadvantages: Dimensional changes of the tracing paper from application of heat. Mylar was not suitable for drying the adhesive since there was too much adhesion to the Renovapapier; a fiberglass sheet coated with teflon was used instead.

- B. Procedure: 1. Mowilith DMC2, 1 part to 15 parts ethyl alcohol, plus 5% Klucil J (hydroxypropylcellulose, Hercules Inc.).
2. Impregnation of carrier, Renovapapier, and continue as above.

Advantages: Renovapapier shows less dimensional change during application of adhesive. There is a stronger adhesion to the original.

Disadvantages: Same as above.

Synthetic Adhesive, Solvent-Activated

- I. As a result of the above tests Hoffenk de Graaf continued to work with Renovapapier, impregnated with PVA emulsion; she sprayed the supports with ethyl alcohol to tackify the adhesive. This system resulted in a form of pressure-sensitive backing without the disadvantages discussed earlier on.

- Procedure: 1. Prepare Renovapapier or Cerex as above.
2. Wet the reverse of the object with ethyl alcohol; also spray the adhesive side of the secondary support with alcohol.
3. Place backing on top of original with adhesive side down.
4. Spray area to be worked with alcohol and use hand or rubber roller to effect adhesion. (Isopropyl alcohol can be used to slow down evaporation.)

Advantages: Ease of application; local control in manipulating smaller areas; the solvent is not as toxic as some. Ease of removal; density of paper, which was a problem for impregnation, is an advantage since the alcohol does not cause penetration of adhesive between the fibers and mechanical removal is possible.

Disadvantages: PVA emulsion could show poor aging characteristics; discoloration and acidity are possible.

Comment: Of all the systems which use synthetic adhesives this one appears to me the most successful one. Dimensional changes through water or heat are avoided; the solvent is not very dangerous to the operator; large objects can be mounted successfully without undue stress on the original.

One might want to experiment with the acrylics or one of the PVA resins.

OILED/RESIN IMPREGNATED PAPERS

- I. In a 1980 article in the AIC Journal, Thea Jirat-Wasiutynski reported the use of a heat-set method for lining of an oil/resin-impregnated laid paper from the early 19th century. Again, as in the work by Hoffenk de Graaf, a textile method was applied to the conservation of paper.

Procedure: 1. PVA AYAF 10% in toluene; spray onto Cerex.
2. Temperature 150°F (65.5°C).
3. Apply iron from the front of the object.

Advantages: Ease of application and removal. Cerex conforms and is practically invisible. PVA is stable, heat is low.

Disadvantages: Toxicity of solvent, local application of heat which can cause deformation of transparent papers.

Comment: One might consider the substitution of a cellulosic carrier. This procedure is not applicable to all resin or resin/oil-impregnated papers, since the natural resins would melt.

- II. In 1981 Christiane Saucois reported a treatment of an oiled paper. Her final choice again derived to some extent from textile and very traditional paper treatment. She chose lamination. The author felt that in this case it was best to treat the original paper support before adding another support. The oil was extracted from the original support which was then buffered and laminated.

Procedure: 1. Extract oil in a bath of methanol and freon 113 (1:1) for 10 minutes.
2. Deacidification by immersion in 500 ml methyl magnesium (magnesium methoxide/CO₂ one l/min for two hours); after absorption of 500 ml, pH of 9.3.
3. Reinforcement by lamination with Cerex, silk (similar to Crepeline), Bifix (thermoplastic polyamide adhesive web).
4. Verso: Cerex, Bifix, object, mend and attach with hot spatula.
5. Recto: Bifix, silk are applied from the front and affixed with a spatula.

- Advantages: Large pieces of oiled paper are extremely brittle and will shatter easily. Lamination provides sufficient rigidity to permit handling. The paper has been buffered. It can be handled safely. The information is preserved.
- Disadvantages: The object has been irreversibly changed.
- Comment: This is a special case. Oils or resins tend to darken the paper support drastically, therefore, while the transparency is lost, the color and strength of the paper are closer to that of the original. However, since the media rest on the oily/resinous surface, removal of the impregnating agent could result in design loss. I question the choice of silk as one of the supports; silk does deteriorate easily and while no treatment lasts forever, one would want to choose materials which endure.

This presentation deals only with transparent papers. There are, however, two more groups of records which will need preservation and where new approaches will be necessary. They are blueprints and tracings on architectural linens. The latter cannot be treated with moisture since the starch used in preparing the supports is hygroscopic and soluble in water. The paper supports of the blueprints and especially the sepia- or brownprints are often very weak, either because the papers used were of poor quality or because the printing process contributed to the long-range deterioration of the papers; these prints are also very sensitive to light. This area of research is of great importance since often blueprints are the only records left of a particular structure; and because they record changes and adaptations in the original plans.

Adhesives used and tested in the conservation literature on tracing papers are: starch, PVA emulsions, PVA resins, acrylics, and polyamides. My preference is a PVA resin or the acrylic emulsions. These resins are more easily soluble, and in a less toxic solvent, than the PVA emulsions.

One might also explore the different drying and finishing processes for aqueous linings. It occurs to me that flattening by an adaptation of an industrial calendering process may enable one to use water-based adhesives such as wheat starch with its proven aging qualities in the treatment of large collections of tracing papers, rather than reserve the aqueous adhesives for small or "valuable" objects.

It appears that of the dry methods, lamination in a heat press is preferable to local application of heat. Spray application of the adhesive of choice is preferable to brush application -- both for appearance of the transparent paper later on and for control of the amount of adhesive. It seems from most accounts that the heat-seal process, no matter what the adhesive, can be easily reversed mechanically, due to the density of transparent papers.

The choice of support poses a problem. I would use paper rather than a synthetic material. Kizukichi, Chumino, and Tengujo are Japanese papers which lend themselves to the purpose, since they are quite transparent; Green's tissue is also transparent, but may not be suitable for large objects.

With regard to method, my preference is for the solvent-activated adhesive system proposed by Hoffenk de Graaf. Its advantages are the possibility of working on small areas at a time, and the ease of making corrections during backing. The solvent, while possibly intoxicating, is not as toxic as the toluene and other organic solvents which have been used. Heat is avoided, and the application is from the backing to the original rather than the other way around, as in some of the heat-set processes.

Like any conservative conservator, I would rather stay with the tried and proven materials, starch and paper. Their use is not without problems since removal may necessitate full immersion in water; this may be injurious to the support and/or design. It also may become necessary to use enzymes to remove the starch adhesive, and the denaturalization of enzymes is still problematic. It is therefore necessary to investigate further and test the synthetic adhesive materials and systems available to us.

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