

The Conservation of Tiffany Studios Drawings: Cases of Complex Paper Reconstruction

ABSTRACT

This article explores the use of paper pulp infills and overlays to reconstruct and reinforce drawings severely damaged by mold. In creating custom-made papers to compensate large support losses and conceal irreversible mold staining, several ideas need to be contemplated regarding the transformations that take place in the paper structure due to biodeterioration. One consideration is the increased susceptibility of hydrolyzed paper to moisture, which results in a differentiated hygroscopicity of fibers within the same drawing. A technique is described that allows the conservator to prepare infills and overlays in a manner that provides sympathetic hygroscopic behavior with damaged areas of paper. The technique also guarantees minimal exposure to moisture during treatment for water-sensitive media. Three case studies from drawings made by the Tiffany Studios illustrate the use of this technique.

TIFFANY STUDIOS DRAWINGS AT THE METROPOLITAN MUSEUM OF ART

Louis Comfort Tiffany (1848–1933), one of America's most celebrated artists, worked in nearly all media available to designers in the late 19th and early 20th centuries: glass, ceramic, metalwork, textiles, jewelry, and painting. The American Wing of the Metropolitan Museum of Art holds a collection of over four hundred drawings from his workshops. The subject matters of these drawings are as diverse as were the catalogues of his legendary design company. They are preparatory sketches, cartoons, and presentation drawings for the myriad objects that the Tiffany companies created with the ideal of bringing beauty into everyday life, whether a lamp on a table or a grand theater.

Trained to be a painter, by the 1870s Tiffany had already begun experimenting with glass-making techniques, and in 1879 he founded his first design company. From then



Fig. 1. Tiffany Studios, Glass Shop. Craftsmen relied directly on drawings during the production phase. From *Character and Individuality in Decorations and Furnishings*, New York: Tiffany Studios, 1913, n. p. Thomas J. Watson Library.

until the mid-1920s, Tiffany ran many interrelated design firms, including the Tiffany Glass & Decorating Company and Tiffany Studios, a prosperous interior design business that revolutionized the look of stained glass. The studios were known to be extremely innovative and dynamic, with hundreds of men and women working under the direct supervision of Mr. Tiffany. In the highly organized operations machinery of the workshops, drawings played a critical role, not only for communication with clients and promotional purposes, but also during the design phase (fig. 1). The study of the Metropolitan Museum of Art's collection opens a window into the various ways the drawings were used. Beautiful works of art in their own right, these drawings provide an extraordinary opportunity to understand the creative process of the Tiffany Studios.

Despite the enormous success that Tiffany experienced over his long career, his firm went out of business in 1924, and Tiffany Studios filed for bankruptcy in 1932. After Tiffany's death in 1933, his estate, including the contents of the studios, was sold in two consecutive auctions. A large number of drawings were bought by the museum in 1967 after they

Presented at the Book and Paper Group Session, AIC's 42nd Annual Meeting, May 27–31, 2014, San Francisco, California.

were discovered in an attic room of a marble dealer in Long Island. The dealer presumably acquired them from the Tiffany Studios when they closed in 1932 or from Laurelton Hall, Tiffany's country estate in Long Island. The historical storage conditions of the drawings are unclear, but when they entered the museum in the 1960s, they were not accessible for proper study or exhibition because they suffered from extensive mold growth due to water damage. The deterioration was so severe that these drawings were tremendously disfigured, structurally unsound, and posed a health hazard for handlers and researchers.

THE EFFECTS OF BIODEGRADATION

The biodegradation of paper is a very complex phenomenon. Fungal and bacterial interaction with media and paper compromises the integrity of the artistic object at two levels: the structural and the aesthetic. Once paper is subject to the enzymatic hydrolysis employed by mold to break down the cellulose molecules for digestion, its intrinsic physical qualities are transformed, and as a result, it not only becomes irreversibly weakened, but also more permeable to moisture. Other phenomena related to mold growth also alter hygroscopicity, such as the destruction or partial disintegration of the sizing and the uneven distribution of the paper filling materials.

The second consequence of biodegradation is the aesthetic alteration of the art object. Pigments and by-products induced by fungi disfigure art in dramatic ways. Pigments are bio-chemically produced by mold to serve several purposes. For instance, black pigmentation attributed to melanin, protects fungal cells from damaging UV radiation.

Extensive research continues to be done by microbiologists and paper conservators with the goal to better understand the destructive processes of mold growth, and find methods that can assist in safely removing fungal body from contaminated paper. Although much has been accomplished in this effort, in many instances conservators are forced to confront the realization that this pigmentation cannot be removed without compromising the integrity of a fragile support.

Decontamination and reduction of mold-produced stains are necessary aspects of the treatment of biodegraded drawings, but they are not the primary focus of this article. Briefly summarized, mold remediation usually involves a set of steps that can range from vacuum cleaning to the use of solvents, enzymes, bleaches, and chelating agents. Given the complexity of biodegradation, the strategy is always devised on a case by case basis. Furthermore, when addressing the cleaning of these drawings, extreme precaution must be taken due to the physical fragility of the damaged paper, but also its accentuated vulnerability to water. Bearing this vulnerability in mind, as well as the inherent susceptibility of watercolors to wet treatments, cleaning strategies are usually devised with a local approach.

Regardless of the level of success of any given treatment, in cases of severe biodegradation it is virtually impossible to bring back the paper to a state close to the original condition, and the damaged areas continue to be weak and disfigured. In these situations, conservators are left with the double challenge of providing structural stability while regaining, to the extent possible, an aesthetic unity. This article describes a reconstruction methodology that seeks to solve both of these challenges.

A TECHNIQUE TO RECONSTRUCT AND REINFORCE DAMAGED SUPPORT

The reconstruction and reinforcement of the damaged support can be accomplished by creating paper pulp infills and overlays with a methodology that takes the principles of traditional Western papermaking and adapts them to the scale of the conservation lab and the specific needs of the damaged artwork.

There are several distinct advantages to this method: it reinforces strata that have been structurally compromised by biological action; it helps to aesthetically improve areas of paper that have been irreversibly stained by fungal activity; the infill and overlay are created separately, preventing the drawing from excessive wetting; it allows to reintegrate large losses with minimal stress applied to the original support; it provides planar stability to objects with differentiated hygroscopic behavior; and it is reversible.

SELECTING THE FIBERS

Many types of papers and pre-processed dry paper pulps have been traditionally used in the field of paper conservation to compensate missing support. In selecting the raw materials to make paper in the lab, conservators have at their disposal an array of native fibers that have been processed in a variety of ways. The conservator's choice of the raw material and method of processing must align with the specific circumstances of each project.

Pre-processed dry paper pulps are refined, partially beaten pulps, where the long raw fibers have already been purified (bleached or unbleached) and separated from each other. These pulps are a convenient option for the purpose of creating custom-made papers in the conservation lab because they offer conservators control over the resulting product. Generally, it is easier to obtain technical specifications about pre-processed paper pulps than it is about machine-made and hand-made sheets of paper, which may contain unknown fillers and additives. Furthermore, these fibers have not been extensively beaten, which provides an opportunity to influence certain features of a fabricated paper, such as percentage of native fiber mixture and fiber length.

The pulps employed in the treatments illustrated in this article, are prepared by several papermakers who create

paper pulps specifically for the field of paper conservation. Alan Buchanan¹ makes pulps from 100 % rag cotton. Arte y Memoria² distributes 100 % cotton, 100 % flax, and mixtures of hemp and cotton that are ECF bleached³ and contain a carboxy methylcellulose internal sizing and a magnesium buffer. Other mills that offer similar materials include: Carriage House Papers⁴, Ruscombe Paper Mill⁵ and Griffen Mill⁶.

Properties such as hygroscopicity and opacity may be considered when selecting types of native fibers and combinations of these fibers. For instance, bast fibers are more hydrophilic than seed fibers due to their hemicellulose content. If both bast and cotton fibers are mixed together when creating an infill or an overlay, the conservator will produce a paper that is more hygroscopically similar to degraded, hydrophilized cotton. It has been observed that this is beneficial during drying and flattening treatments because it prevents the formation of tensions between the damaged paper and the infill or overlay.

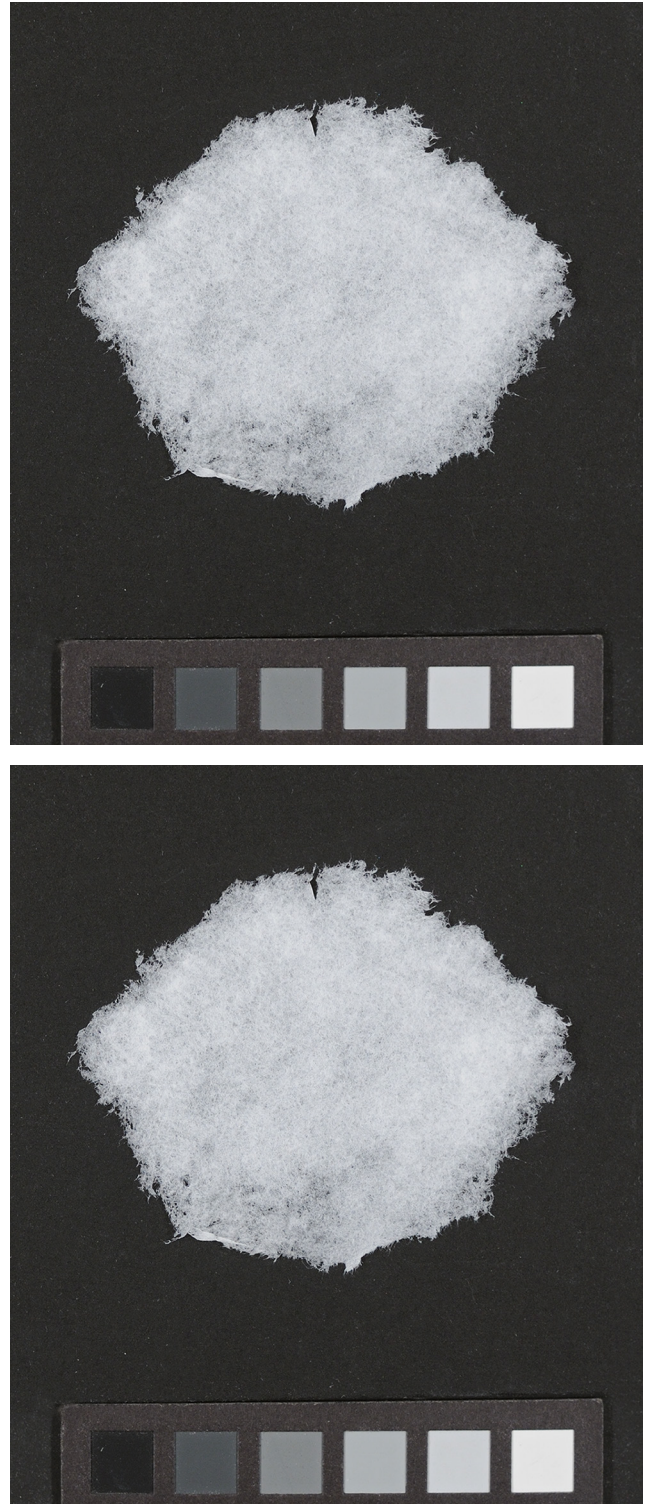
The opacity of fibers is significant as overlays can be used to hide stained areas of a drawing. For example, flax and hemp are more opaque than cotton and are better options for creating thin overlays with high covering qualities (figs. 2a–2b).

COLORING THE PAPER PULP

Another advantage of creating custom infills and overlays from pulp is that the conservator can make them close in color to the healthy paper of the artwork. This can be achieved in many ways. Coloring methods can include: using colored papers; using pre-dyed paper pulp; dyeing natural paper pulp; adding pigments to natural paper pulp; and adding colored media (such as acrylics or watercolors) to paper pulp or to the formed sheet of paper.

Many papermakers who distribute products for the field of paper conservation offer in their catalogues, colored dry paper pulps. Alan Buchanan follows the method developed by Ruth E. Norton to prepare pulps of the three primary colors at different Depths Of Shade (DOS) with fiber-reactive dyes (Buchanan 2008). Arte y Memoria offers a selection of pre-dyed pulpboard that includes a maroon mixture of cotton and hemp that is colored with direct dyes. There seems to be a consensus that fiber-reactive dyes are in general more light-fast than direct dyes.

Natural pre-processed paper pulp can also be colored with pigments, which in ideal conditions are the most lightfast colorants. Pigments need to be bonded to the paper fiber with the aid of a cationic agent. In her book *Color for the Hand Papermaker* (Koretsky 1983), Elaine Koretsky, offers detailed instructions for papermakers to optimize the use of stable pigments and dyes. One issue that conservators confront when working with these products is often the undesired bleeding of unfixed pigments and dyes. Another related complication is the relocation of unfixed pigments during casting,



Figs. 2a–2b. In these two comparative images, it is possible to observe how a 0.06 mm paper made of 100% flax fibers (below) is more opaque than a 0.06 mm paper made of 100% cotton fibers (above).

which can produce mottled papers. In addition, watercolor and acrylic colors can also be employed in the slurry or in the form of glazes.

Creating a specific color of pulp can be challenging. It requires trial and error and continued empirical analysis. However, the results that can be achieved, justify the effort.

BLENDING THE PAPER PULP

Pre-processed dry pulps need to soak in water to ensure the fiber swelling that is necessary for the formation of flexible paper. After the pulp has soaked long enough to fully absorb the water and swell, it is beaten in a food blender, where the bundles of different colored fibers are separated, mixed, partially cut and fibrillated. In ideal conditions, this process would take place in a beater or a hydro-pulper, but considering the small amounts of pulp that conservators need to prepare for each project, food blenders are good substitutes⁷. The blending time and speed will vary depending on the native fiber (for instance, bast fibers fibrillate more easily than cotton) and the desired characteristics of the paper—strength, thickness, opaqueness and uniformity. The formed paper will have different qualities depending on fiber length and the extent of fibrillation—shorter fibers, for example, will produce a weaker more uniform paper.

The consistency of the slurry, the amount of dry solid content in water, determines the thickness of the formed paper. Before preparing the slurry, the ratio of dry paper pulp to water is calculated in order to form paper of a specific thickness. Table 1 can be used as a reference (table 1).

CASTING INFILLS AND OVERLAYS

Once the slurry is ready, a Mylar template is made by marking both the losses and the areas to cover with an overlay (fig. 3). By principle, areas that contain media will not be covered and will be reinforced only from the back.

A screen is prepared with a sheet of Hollytex⁸ attached with tape to a plastic frame. Used together, these materials approximate the moulds employed in traditional Western sheet forming, but are more useful within the context of a paper conservation lab. The template is placed on a light table



Fig. 3.

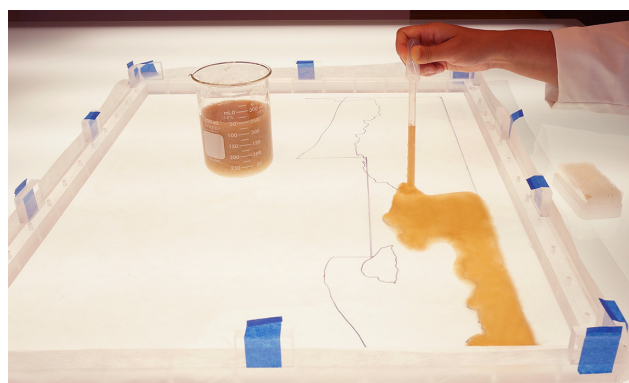


Fig. 4.



Fig. 5.

Dry paper pulp	Total volume paper pulp and water	Thickness of formed paper
3.0 gr	250 ml	0.25 mm
2.5 gr	250 ml	0.15 mm
1.5 gr	250 ml	0.08 mm

Table 1.

and the screen over it. Plastic pipettes⁹ are used to pour the pulp over the screen following the contours of the template that are made visible with the transmitted light (fig. 4).

A gentle vertical tapping is performed with a brush (corn brush or sensory brush)¹⁰ to avoid entanglement and flocculation and also to evenly distribute fibers in-plane (fig. 5). This approximates the leveling effect achieved by a papermaker after pulling a mould out of the vat and shaking it, which also evens the fiber orientation and gives the formed paper its directional strength properties.

DRYING THE CAST SHEET OF PAPER

In traditional hand papermaking, the pulp is dewatered by filtration, pressed and dried to form a web structure—the sheet of paper. In the lab, we can simulate this process using a series of steps. After the paper has been formed, the screen is lifted vertically creating a pulling effect and deposited over an absorbent material, such as a wet blotting paper. Blotters filter the water in a manner that is equivalent to what happens during the traditional couching. The paper is dried on the suction table between two sheets of Hollytex and two dry blotters. The applied pressure provides a restraint that guarantees the dimensional stability of the paper (fig. 6). This is just one method of many to dry cast paper. Other alternatives can be used for practical purposes and to alter the character of the formed sheet¹¹.

ATTACHING INFILLS AND OVERLAYS TO THE ARTWORK

Two papers are cast consecutively, an infill and an overlay. The infill must have the shape of the losses and must be as thin as the adjacent areas of the drawing; the overlay must be thinner and will cover the losses as well as the pigmented areas to be concealed.

The infill is first attached to the artwork using wheat starch paste (fig. 7). The artwork is then ready to be gradually humidified in a chamber in preparation for the second step, the attachment of the overlay.

Before bringing the drawing out of the humidity chamber, a diluted solution of cooked wheat starch paste (10% v/v) is mixed in the blender and placed in an air-brush bottle. The diluted paste will reinforce the hydrogen bonding that forms among the fibers, while still making the overlay reversible.

The artwork is then placed on the suction table, and after making sure that it is completely flat and free of creases, a protective blotter is placed over it, leaving exposed the area that will be covered by the overlay.

The paste is slowly applied with the air-brush over the damaged areas of the art, and the overlay, which has been pre-humidified and placed face down onto a piece of Mylar for easier handling. The overlay is then carefully positioned on

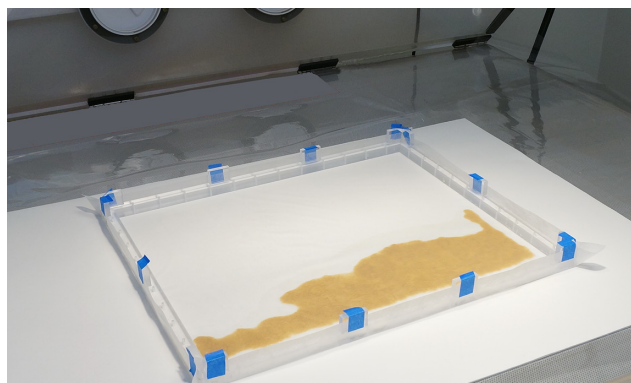


Fig. 6.



Fig. 7.

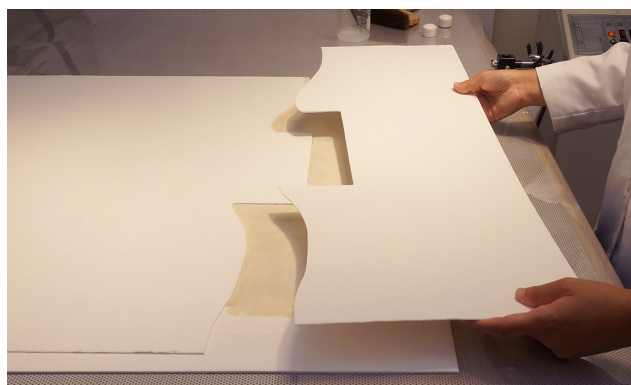


Fig. 8.

the artwork, and after making sure that the contact between the two papers is even, the artwork is covered with a layer of Hollytex and a thick blotter until drying is complete (fig. 8). Finally, the drawing is flattened by humidifying it in a chamber and placing it under weight for several weeks. This last step is recommended to release any tension on the drawing that may have formed during drying on the suction table.

FIRST CASE STUDY: *DESIGN FOR A MOSAIC PANEL*

Design for a Mosaic Panel is a sketch painted with watercolor over an illustration board by Frederick Wilson, one of Tiffany's most distinguished designers (fig. 9). This exquisite drawing is one of the few examples in the collection of a design for a figurative mosaic.

Given the multilayered structure of these drawings, which are often attached to backing boards and mat windows, conversations with the curatorial department determine if prior to decontamination, the removal of the attached elements is advisable in light of their historic relevance. In some instances, like in *Design for a Mosaic Panel*, removing them is necessary to gain access to all the laminated layers and guarantee the correct preservation of the primary support.

In preparation for the backing removal, areas of the primary support that seemed structurally compromised were temporarily reinforced on the recto with small strips of remoistenable tissue prepared with 8% (w/v) Klucel G. The tissue strips were reactivated with ethanol, which prevented the formation of tidelines. Backing removal was accomplished with mechanical means, and decontamination on the verso was completed. After a thorough surface cleaning, reduction of discolorations and stains were performed locally on the suction table with a series of solvents, enzymes and chelating agents (fig. 10). The drawing was ready for the next series of steps to the reconstruction of the support, which was performed following the above-mentioned infill and overlay technique. The paper for the overlay was prepared by mixing cotton, flax and hemp in the following proportions: 2 gr yellow DOS ½% (Alan Buchanan), 1.4 gr maroon mixture of cotton and hemp (Arte y Memoria), and 1.6 gr white flax (Arte y Memoria) in 500 ml deionized water. Blending time was 30 minutes at medium speed, which produced an opaque, soft and evenly distributed thin paper that featured the right qualities to reinforce the damaged areas of support.

Once the reinforcement of the damaged support on the recto was completed, the damaged areas that affected media were reinforced on the back with Tengucho paper and diluted wheat starch paste. Small areas of missing color on the lower right corner of the design were retouched by applying watercolor over the infill paper in a neutral tone matching the surrounding colors. Even though the drawing still exhibits scars from the severe damage it once sustained, this procedure was effective in returning the artwork to a state where it can be contemplated without the distraction of severe staining, and most importantly, it can be safely handled, photographed and exhibited (fig. 11).



Fig. 9. *Design for a Mosaic Panel*. Frederick Wilson, Tiffany Studios. 1902–1932. 53 x 71.8 cm. (Museum accession number 67.654.36). Before treatment.



Fig. 10. *Design for a Mosaic Panel*. During treatment.



Fig. 11. *Design for a Mosaic Panel*. After treatment.



Fig. 12. *Design for wood and fabric screen for Church of the Ascension, New York City*. Tiffany Studios. 1902–1932. 37.9 x 54.9 cm. (Museum accession number 67.654.413). Before treatment.



Fig. 13. Steps were cut along the resected edge, and multiple layers of paper were used as reintegration material.



Fig. 14. *Design for wood and fabric screen for Church of the Ascension, New York City*. After treatment.

SECOND CASE STUDY: *DESIGN FOR WOOD AND FABRIC SCREEN*

When addressing the conservation of *Design for an Organ Screen* (fig. 12), a drawing commissioned for the Church of the Ascension, in New York City, it was decided that since the backing was historically relevant, only the severely mold contaminated areas with no inscriptions would be removed. The damaged areas of the primary support were decontaminated and cleaned.

Preserving the laminar structure meant that the areas of loss needed to be compensated. Three-dimensional reconstruction had to be accomplished in a way that created as little stress as possible to an inherently weak support.

The following method is successful in that it avoids adding tension to the original boards while remaining structurally solid and aesthetically sympathetic. Several steps were cut along the resected edge to increase adhesion area, and multiple layers of paper were used as reintegration material (fig. 13). The preferred material was a handmade rag paper from the Richard du Bas Mill in France¹². Manufactured mostly for printing, these waterleaf papers are particularly soft and have optimal dimensional response when subject to moisture and the right amount of pressure. They were cut with precision to align with the individual steps and attached to the artwork as well as to each other with 5% (w/v) 4M methylcellulose, which was chosen in this case for its weak adhesion power and minimal shrinkage during drying. Once all layers were assembled, they dried under pressure for several weeks. When the attached infill was completely stable, the edges were trimmed to fit the exact dimension of the drawing and color was added to the sides with watercolor. Final layers of paper were cast to match the characteristics of the original papers. The paper for the overlay on the recto was prepared by mixing cotton, flax and hemp in the following proportions: 0.9 gr yellow DOS ½ (Alan Buchanan), 0.8 gr maroon mixture of cotton and hemp (Arte y Memoria), and 0.8 gr white flax (Arte y Memoria) in 250 ml deionized water. Blending time was 30 minutes at medium speed, which produced an opaque, soft and evenly distributed thin paper. The paper for the overlay on the verso was prepared with Alan Buchanan rag cotton fibers mixed in the following proportions: 1.5 gr DOS 4% yellow, 0.3 gr DOS 4% red and 1.2 gr DOS 4% blue (equivalent to Buchanan's DOS 4% 5Y 1R 4B swatch). Blending time was 5 minutes. A final glaze of burnt sienna acrylic was air-brushed to the formed paper. These two papers were attached to the recto and to the verso by air-brushing a 10% (v/v) solution of cooked wheat starch paste over the pre-humidified cast papers, attaching them over the areas that needed to be concealed, and letting the object dry under weight for several weeks.

In this case, a more integrated restoration was desired, and modulations of color that blend with the natural discolorations of the paper around the edges were added in the form

of thin glazes of acrylic pigments applied by air-brush after masking out the artwork (fig. 14). Ethical considerations are always addressed when adding such large portions of support to an art object, but in cases like this, when the area of the drawing that is being retouched is so extremely disfigured and it affects only the margin and not the design, it is easier to make the choice of covering the original.

THIRD CASE STUDY: *ANGEL APPEARING TO THREE MARYS AT THE TOMB*

The final study is the conservation treatment of *Angel with Three Marys* (fig. 15), a design for a leaded glass window. In this example, important inscriptions were present on the upper margin and needed to remain uncovered for future research¹³.

The inscriptions regained legibility after decontamination and cleaning, and once the backing removal was completed, it became apparent that important fragments on the top area were detached from the main body and that the drawing had large losses that affected the design (fig. 16). Paper pulp was used to cast infills of the right thickness and shape, and they were attached to compensate for the missing support. It was decided that a paper pulp overlay would be used to cover the areas of the design that were irreversibly stained by black

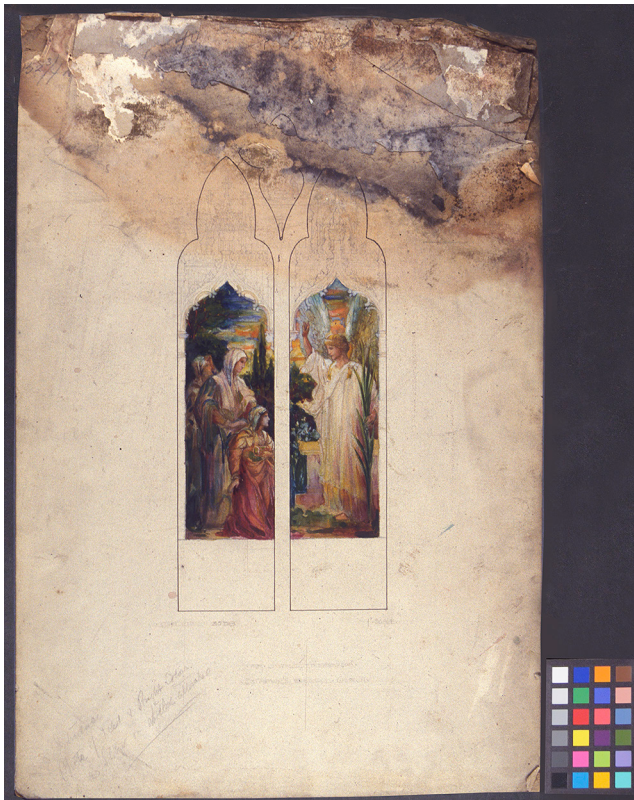


Fig. 15. *Angel Appearing to Three Marys at the Tomb*. Tiffany Studios. 1902–1932. 55.7 x 37.1 cm. (Museum accession number 67.654.206). Before treatment.



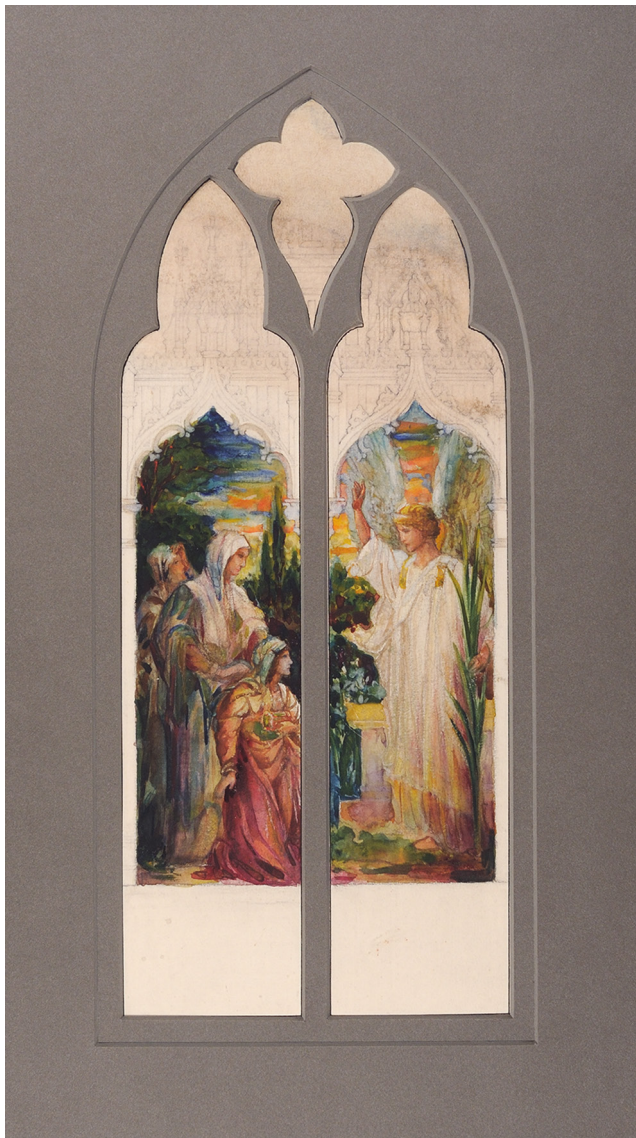
Fig. 16. Detail of the drawing during treatment, showing detached support and losses that affect the design.



Fig. 17. Image of the fabricated overlay. The paper was cast to avoid covering inscriptions and cut to precision where lines of ink should be exposed.

melanin, but that the overlay should not conceal the inscriptions. The paper for the overlay was prepared by mixing cotton, flax and hemp in the following proportions: 0.8 gr yellow DOS ½% (Alan Buchanan), 0.7 gr maroon mixture of cotton and hemp (Arte y Memoria), and 1 gr white flax (Arte y Memoria) in 250 ml deionized water. Blending time was 30 minutes at medium speed. The areas of the paper corresponding to lines of black ink marking the contour of the windows in the design were cut out so that when the paper was adhered to the drawing, the media would remain fully visible (fig. 17). Adhesion was accomplished on the suction table with the described technique and the overall damaged area was reinforced on the verso by providing a partial lining with a thin Tengucho.

Given the hybrid nature of this drawing, part historic record, part work of art, it was decided that the missing parts of the ink lines should not be reintegrated. The areas of overlay around the design were toned to match the surrounding paper and the mat window was cut to suggest the full shape of the top quatrefoil and the right arch (figs. 18a–18b).



Figs. 18a–18b. *Angel Appearing to Three Marys at the Tomb*. After treatment.

CONCLUSIONS

Support reconstruction techniques with paper pulp can yield successful results in the stabilization and compensation of mold damaged works of art on paper. Considerations such as the characteristics of the native fibers, how their processing impacts the character of the formed paper, and the susceptibility to wet treatments of mold-degraded paper, can have a positive impact in creating a sympathetic interaction between the art work and the reintegration materials.

ACKNOWLEDGEMENTS

The author gratefully acknowledges all members of the Sherman Fairchild Center for the Conservation of Works on Paper at The Metropolitan Museum of Art for their support and feedback; Alice Cooney Frelinghuysen, the Anthony W. and Lulu C. Wang Curator of American Decorative Arts at The Metropolitan Museum of Art, for her encouragement and scholarship on the work of Louis Comfort Tiffany; papermaker and printer Shaye Remba for his wisdom; The Metropolitan Museum of Art and The Institute of Museum and Library Services for jointly funding the project under which these treatments were developed; videographer Steve Zehentner and photographer Patrick Perry for their audio-visual contributions to the project; the Foundation of the American Institute for Conservation of Historic and Artistic Works, for generously awarding the author a Carolyn Horton and a Christa Gaehde grant to present this project at the 2014 AIC Annual Meeting.

NOTES

1. See Alan Buchanan in *Sources of Materials*.
2. See *Arte y Memoria* in *Sources of Materials*.
3. ECF stands for Elemental Chlorine Free.
4. See *Carriage House Papers* in *Sources of Materials*.
5. Ruscombe Paper Mill pulps are distributed by Talas. See Talas in *Sources of Materials*.
6. See Griffen Mill in *Sources of Materials*. They only take special orders for dry leafcasting pulp.
7. The model used by the author is a Vitamix Vita-pre3.
8. Different materials were tested that would allow the paper fibers to stay in suspension while remaining dimensionally stable. These included several non-woven polyester fabrics, rayon tissues and wet-strength paper tissues. Hollytex (thickness: 0.0029" +/- 0.0007) was found to have optimal qualities for this purpose.
9. See Fischer Scientific in *Sources of Materials*.
10. See Pacific Pediatric Supply in *Sources of Materials*. There are many online distributors of corn or sensory brushes.
11. Optional couching materials can include sponges, wool felts, and absorbent synthetic papers (Evolon AP, Tek-Wipe). Optional pressing and drying techniques can include traditional press between absorbent

materials, printer's press—drying stack built up with interspersed corrugated boards, with cold air and hot air—and stretch-drying.

12. See Moulin Richard de Bas in Sources of Materials.

13. The inscriptions revealed during conservation helped in the identification of the window made from this design as one from St. Mark's Episcopal Church in Salt Lake City, Utah.

SOURCES OF MATERIALS

Alan Buchanan Designs Ltd

www.alanbuchanandesigns.com

3 Arlington Cottages

Sutton Lane North, London

W4 4HB, United Kingdom

Tel: +44 (0)208 995 9780

e-mail: abuchanan880@gmail.com

Product description: dry pre-processed pulp

Arte y Memoria

www.arteymemoria.com

Industria, 26

08551 Tona

Barcelona, Spain

Tel: +34 938 125 378

e-mail: comercial@arteymemoria.com

Product description: dry pre-processed pulp

Carriage House Paper

www.carriagehousepaper.com

245 Kent Avenue

Brooklyn, New York

11249 USA

Tel: +1 718-599-PULP (7857) or +1 800-669-8781

e-mail: info@carriagehousepaper.com

Product description: colorants and additives

Fischer Scientific

www.fishersci.com

Tel: +1 800-766-7000

Product description: Fisherbrand™ Transfer Pipettes.

Length: 5.875 in. (15cm); Capacity: 7.7mL

Catalog No.: 13 711 7M

Griffen Mill

www.griffenmillhandmadepaper.com

Killinagher

Ballyhaunis (County Mayo), Ireland

e-mail: griffenmill@eircom.net

Product description: dry pre-processed pulp

Moulin Richard de Bas

www.richarddebas.fr

F-63600 Ambert, France

Tel: 33 (0) 473 820 311

e-mail: rdb@wanadoo.fr

Product description: paper (Blanc narcisse, vergé canton, 90-120 g/m²)

Pacific Pediatric Supply

www.pacificpediatricssupply.com

Product description: corn or sensory brush

Talas

www.talasonline.com

330 Morgan Ave

Brooklyn, NY 11211

Tel: +1 212-219-0770

Product description: dry pre-processed pulp

REFERENCES

- Balston, John Noel. 1998. *The Whatmans and Wove Paper: Its Invention and Development In The West: Research into the Origins of Wove Paper and of Genuine Loom-Woven Wire-Cloth*. West Farleigh, Kent: John Balston. Addendum: 228–230.
- Baldwin, Ann. 2003. "An Introduction to Tiffany Studies." *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: Metropolitan Museum of Art: 83–93.
- Banik, Gerhard, Irene Brückle, and Vincent Daniels. 2011. *Paper and Water: A Guide for Conservators*. Amsterdam: Butterworth-Heinemann.
- Bayldon, Oliver, Rigby Graham, and Jean Imberdis. 1965. *The Paper Makers Craft*. Leicester [England]: Printed by Will Carter at Cambridge for the Twelve by Eight Press.
- Bolton, Tom. 2009. *Shake*. [London]: British Association of Paper Historians.
- Buchanan, Alan. 2008. "A Methodical Visual System to Create Matching Infills for Missing Areas in Works of Art on Paper by Dyeing Cotton Rag Papermaking Pulp in Different Shades of Yellow, Red and Blue." *The Quarterly* 65: 20–28.
- Busker, L. H. 1986. "Effects of Wet Pressing on Paper Quality." *Southern Pulp & Paper* 49 (2): 23–25.
- Céline, Amandine, Sylvain Fréour, Frédéric Jacquemin, and Pascal Casari. 2013. "The Hygroscopic Behaviour of Plant Fibers: A Review." *Frontiers in Chemistry* 1:43 <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3982556/> (accessed May 20, 2014).
- Ciferri, Orio, Piero Tiano, and Giorgio Mastromei. 2000. *Of Microbes and Art: The Role of Microbial Communities in the Degradation and Protection of Cultural Heritage*. New York: Kluwer Academic/Plenum Publishers.
- Di Bonaventura, Maria Pia et al. 2003. "Studies of Fungal Infestations of Tiffany Drawings: Limits and Advantages of Classical and Molecular Techniques". In *Art, Biology,*

- And Conservation: Biodeterioration of Works of Art*. New York: Metropolitan Museum of Art: 95–109.
- Florian, Mary Lou Esther. 2002. *Fungal Facts: Solving Fungal Problems in Heritage Collections*. London: Archetype 1–98.
- Florian, Mary Lou Esther. 2000. “Fungal Fox Spots and Others.” *Of Microbes and Art: the Role of Microbial Communities in the Degradation and Protection of Cultural Heritage*. New York: 135–151.
- Frelinghuysen, Alice Cooney. 1999. *Louis Comfort Tiffany at the Metropolitan Museum*. New York: The Metropolitan Museum of Art.
- Futernick, Robert. 1983. “Leaf Casting on the Suction Table.” *Journal of the American Institute for Conservation* 22 (2): 82–91.
- Hamm, Patricia D. 2003. “Second Generation Wet Paper Pulp.” *The Book and Paper Group Annual* 22: 27–31.
- Hamm, Patricia D. 2006. “Dry Paper Pulping.” *The Book and Paper Group Annual* 25: 69–70.
- Keyes, Keiko. 1976. “A Manual Method of Paper Pulp Application in the Conservation of Works of Art on Paper.” *The Paper Conservator* 1: 33–34.
- Koestler, Robert J. 1991. *Biodeterioration of Cultural Property*. London: Elsevier Applied Science.
- Koretsky, Elaine. 1983. *Color for the Hand Papermaker*. Brookline, Mass., U.S.A.: Carriage House Press.
- Koretsky, Elaine. 1988. “The Coloring of Pulp in Alkaline Papermaking.” *Alkaline Paper Advocate* 1 (4): 1–4.
- Letnar, Meta Černič, and Jedert Vodopivec. 2004. “Optimizing the Leafcasting Technique.” *Restaurator* 25: 1–14.
- Nieto-Fernandez, Fernando E. et al. 2003. “Enzymatic Approach to Removal of Fungal Spots from Drawings on Paper.” *Art, Biology, and Conservation: Biodeterioration of Works of Art*. New York: Metropolitan Museum of Art: 111–127.
- Nittérus, Mattias. 2000. “Ethanol as Fungal Sanitizer in Paper Conservation.” *Restaurator* 21 (2): 101–115.
- Norton, Ruth E. 2002. “Dyeing Cellulose-Fibre Paper with Fibre-Reactive Dyes.” *The Paper Conservator* 26: 37–47.
- Odintsova, O.I., M. N. Krotova and B.N. Mel’nikov. 2009. “Use of Cationic Agents for Fixing Coloration of Textile Materials.” *Russian Journal of Applied Chemistry* 8 (3): 461–465.
- Oger, Brigitte. 1996. “Fastness to Light and Washing of Direct Dyes for Cellulosic Textiles.” *International Institute for Conservation of Historic and Artistic Works* 41 (3): 129–135.
- Pepall, Rosalind M. 2009. *Tiffany Glass: a Passion for Colour*. Montreal: Montreal Museum of Fine Arts.
- Shore, John. 1996. “Advances in Direct Dyes.” *Indian Journal of Fibre & Textile Research*. 21 (1): 1–29.
- Sitholé, Bruce B. 1995. “Pulp and Paper.” *Analytical Chemistry* 67 (12): 87R–95R.
- Szczepanowska, Hanna, Thomas G. Mathia, and Patrice Belin. 2014. “Morphology of Fungal Stains on Paper Characterized with Multi-Scale and Multi-Sensory Surface Metrology.” *Scanning* 36: 76–85.
- Szczepanowska, Hanna and Charles M. Lovett Jr. 1992. “A Study of the Removal and Prevention of Fungal Stains on Paper.” *Journal of the American Institute for Conservation* 31 (2): 147–160.
- Turner, Silvie, and Brigit Skiöld. 1983. *Handmade Paper Today, a Worldwide Survey of Mills, Papers, Techniques, and Uses*. London: Lund Humphries.
- Vodopivec, Jedert, Stanka Grkman, and Mata Černič Letnar. 2005. “Leafcasting: the Influence of Starch and Methyl Cellulose Sizing on the Properties of Leafcasted paper.” *PapierRestauration* 6 (3): 30–36.

MARINA RUIZ MOLINA

Assistant Conservator

Metropolitan Museum of Art, the Sherman Fairchild Center
for the Conservation of Works on Paper

New York, New York

marina.ruiz-molina@metmuseum.org