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Recapturing the Subtleties

INTRODUCTION

If one thing is well established in the literature, it is that paper conservation is a delicate balancing act. The paper conservator weighs treatment considerations heavily, first and foremost regarding whether the artwork in question should be subjected to intervention. The deciding factors are numerous, but among them are the availability of tools to solve the identified problem and the conservator's confidence to use them. This paper will focus on the problem of staining and discoloration in paper, as well as the parameters of treatment options currently available to affect these problems.

The nature of staining can be vast, with internal and external culprits. Much study has gone into identifying the specific components of stains, from tide lines to foxing to light exposure, among others. Stains and discoloration are qualified by the custodian: sometimes valued and retained as evidence of the life of the object, and other times considered an aesthetic blight or physically destabilizing element that must be removed. Often it is left to the conservator to decide the safety and reasonability of stain removal, given the range of the evidence the conservator has gathered during examination.

The solutions to condition concerns can be thought of as a set of tools in a toolbox. The paper conservator's toolbox has expanded over the years, and the techniques that will be described constitute an addition to the array of devices that are already present. A good tool becomes more familiar over time, wears nicely, and becomes second nature to the user. The methods presented here are meant to be complementary to those that paper conservators already use.

BALANCING THE RISKS

The responsibility of caring for art is given to conservators because they have been taught a variety of ways to deliver this care, ranging from removing an artwork from view in an effort to preserve for the future to treating severe damage in an effort to restore the object to its aesthetic or physical balance. In between, conservators have a wide range of treatments with a wide variety of deciding factors: the skill of the conservator, the decided level of intervention, and the tools available to perform the task. Sometimes these factors are also dictated by the personality of the conservator, as well as the conservator's treatment evolution and approach.

The discussion begins on the scale of intervention—that is, where treatments fall on the continuum of invasiveness. It is common for a practicing conservator to come across someone else's treatment of an artwork; their reaction to that treatment, and the realization that someone will likely encounter the conservator's treatments in the future, checks the degree of willingness to intervene.

In Irene Brückle's essay *Aqueous Treatment in Context* (Banik and Brückle 2011), she expertly outlines the considerations and conundrums that the paper conservator faces in composing a treatment plan. She establishes that "treatment abstinence" can cause as much harm to the object as active treatment, and that conservators' decisions carry risks and benefits that vary based on the context of the artwork and the specific condition of the piece in question. Reminders of the artwork's physical characteristics, and their relationship to each other, are critical to the decision-making process, which Keiko Keyes astutely recognized early in paper conservation's history: "The interplay of the paper with the medium is always crucial to the visual effect. In treating works of art on paper we must be aware of the subtle qualities of texture, tone, and three-dimensionality that they have, and adjust our methods of treatment to preserve these qualities" (1978, 6).

These subtle characteristics, or rather the paper conservator's recognition of them, are what helps the conservator formulate a treatment that is respectful of the artwork and the passage of time.

TREATMENT OBJECTIVES

This paper will deal specifically with the treatment considerations of stains and discoloration within paper conservation. It will not be an attempt to scientifically evaluate the reduction or removal of stains; rather, an exploration of treatment nuance and intuition will be investigated in an effort to

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illustrate the theories of new techniques of stain reduction. With this in mind, three goals in treatment of stains have been identified:

» *Treat stains efficiently and effectively.* Treatments should be reasonable in time, considering the duration of intervention and the expectation of the custodian. The damage should be aesthetically reduced or physically removed.
» *Retain as much original material as possible.* To conserve infers retention of the original. Every effort should be made to only remove evidence of damage, striving to leave as much as possible untouched.
» *Consider the interaction of the media with the paper.* The artwork is not singular in its materiality, and treatment of one component must take into consideration the whole object.

A certain genre of treatment techniques can be identified as "all-in"—that is, intrusive and irreversible. Others can be slow and steady, with changes nearly imperceptible between applications, but still effective. The conservator learns to identify unique characteristics of treatment techniques and balance them based on the situation. The power of control is paramount, and knowing when to stop is perhaps more important than knowing when to press forward.

CONSIDERATIONS

One of the essential points that is emerging as a key component of treatment with subtlety and control is conductivity. Hughes and Sullivan (2016) have explained the concept of conductivity and how the conservator can adjust it within a solution. To give a brief explanation, conductivity is a measurement of how well an aqueous solution conducts electricity. It is conductive only when ions are present, so it is inferred that when there is no, or very low, conductivity, there are very few ions. When there is high conductivity, the ions within the water are also high.

Figure 1 shows a chart of solutions that are commonly used in paper conservation. For a point of reference, the typical conductivity of the surface of paper is between 50 and 250 microSiemens/cm when measured with an agarose pellet, depending on the damage and the components of the paper. Notice that these numbers fall into two different ranges: low with the aqueous solutions, and high with the chelators and a reducing bleach. This serves as a point of reference to start thinking about the conductivity of the treatment materials used by paper conservators.

Conceptually, then, conservators consider conductivity and how it relates to the artwork, and how it relates to the damage that they are intending to treat. The term *tonicity* refers to the idea that two solutions have ionization, and how they relate to each other falls into three categories: hypertonic, hypotonic, and isotonic. A hypertonic solution has more ions than the other solution, whereas a hypotonic solution has less. Isotonic solutions have more or less equal ionization. The idea is that ions within a solution prefer to find equilibrium.

Aqueous Treatment Solution	Conductivity
Deionized water	0 µS/cm
Calcium Hydroxide in water, prepared to pH 7	6 µS/cm
Ammonium hydroxide in water, prepared to pH7	2 µS/cm
Diammonium Citrate, 1%	7.3 mS/cm
Triammonium Citrate, 1%	9.2 mS/cm
Sodium borohydride, ¼%	5.8 mS/cm

Fig. 1. Selection of solutions used in paper conservation.

Many paper conservators have been taught that washing paper in deionized water can adversely affect the paper and media, which is one of several reasons that water is conditioned with a salt such as calcium, magnesium, or ammonium hydroxide. With the additions, conservators are trying to stabilize the pH, exercising a degree of control on the aqueous solutions. After years of study comparing washing in deionized water versus washing in calcified water, the latter has proven to be more beneficial to the paper, increasing fold strength, reducing acidic by-products, and generally improving the aesthetic result more than that of washing in deionized water. The merits of conditioning aqueous treatment solutions are indisputable.

However, consider what have been identified as the subtleties of a work of art on paper. Going back to the chart of conductivity of solutions (fig. 1), it is apparent that paper conservators are using things that are very hypotonic or very hypertonic on paper, media, and stains. In certain treatment circumstances, introducing high or low ionic activity is quite useful. But consider what benefits there might be if one could use an aqueous solution that matches the conductivity of the paper, media, or both. Soluble acidic by-products would certainly still be taken away from the artwork, as it is in an aqueous solution. Hydrogen bonding will still be restored within the cellulosic structure. But because the solution is close in conductivity to the paper and its components, the possibility has increased that original material such as sizing has been mostly retained within the paper. More importantly, the amount of swelling in the paper is significantly decreased, allowing better retention of the original surface and less likelihood that the media will sink or otherwise be affected by structural changes in the sheet. Furthermore, by using controlled application of chelators in gels, staining materials can be physically removed rather than simply decolorizing them with a bleaching agent.

This system for the treatment of stains and/or discoloration on paper can be broken down into several elements, each of which can be adjusted to suit the need of the artwork. The elements are pH, conductivity, delivery method, and modifiers. The pH and conductivity are self-explanatory, each working on their own scale up or down for a desired effect. The delivery method can be varied: an overall bath, an aqueous spray, swabbing, or gels, among others. Modifiers to the aqueous solutions and the delivery methods are often chelators or enzymes, an additional element that goes beyond manipulation of the pH and conductivity. The intention is to control these elements individually to treat only what is necessary, identifying the precise requirement for our treatments and introducing nothing more.

As with all treatment methodologies, testing informs the decision making for this treatment system. The manner of testing is slightly different from traditional methods and informs slightly differently as well. To start, small pellets of 5% agarose are placed on the surface of the paper, stain, and sometimes media (if it is being treated) for a number of minutes, usually between 5 and 10. The pellets are then transferred to the separate wells of the pH and conductivity meters, and readings are taken. The readings start to help inform paper conservators of the characteristics of the materials and how they might relate to each other.

There are two important things to note during this stage. First, remember that a microtreatment has been performed on the paper, stain, or media. Did the paper swell? Did the gel draw up discoloration? Was the gel too wet and now there are tide lines? These are observations that will be pieced together before the treatment is scaled up. It is also important to note that at every stage, treatments are observed both in visible and UV illumination. UV light shows how the stain and treatment are progressing and if further staining could possibly arise after the artwork leaves the studio.

Second, the interpretation of the numbers is important to understand. The readings are an approximation of the situation that is relevant to the paper, a broad indicator, but do not consider it absolute. It may help to reconsider what happened during the testing: by diffusion, material was solubilized from the paper or from the stain and was drawn up with capillary action into an agarose pellet. Surely not everything was drawn up into the gel, and surely not everything was solubilized during the testing. However, from experience, it is evident that the resulting numbers are useful in informing conservators of the similarity or disparity between the paper and the stain. In testing and interpretation, it is helpful to think about these as relationships, not absolutes.

Once the testing and micro-observations are complete, conservators can start to formulate a treatment that will modulate their intervention. Remember, the overarching goal in this methodology is to reduce evidence of intervention, to leave as little trace as possible indicating that conservators were ever there. Keeping this in mind, conservators assess their tests and the object and ask, did it do anything? If there was any change whatsoever, this is the key to treatment with subtlety. Even the most minute shift, when repeated, can result in a treatment that has little overall effect on the artwork but reduces the presence or appearance of damage.

PRACTICAL APPLICATIONS

Figures 2 and 3 are of a small graphite drawing on cream wove paper from the mid-19th century. It had a distinctive mat burn and overall discoloration, with some orange oil-like discoloration in the center of the bottom edge. In previous treatment methodology, the authors may have float or blotter washed the drawing several times with calcified water, knowing that the overall discoloration would reduce, and hoping that the mat burn would diffuse. If treatment of the mat burn were unsuccessful, then a low-percentage reducing bleach might be used, such as sodium borohydride, to diffuse the distinct line, followed by at least one more overall wash. The bleach might have also been used on the orange staining, or it might be reduced on the suction platen with alternating acid/base water, or solvents.

Instead, the authors tried to stay as light as possible, affecting change slowly and only to the point that was necessary. First, the mat burn was locally reduced and diffused around the perimeter with a chelator gel, in this case citric acid adjusted to a pH of 6.0 and suspended in an agarose gel, and followed this with an agarose gel rinse. The orange stain at the bottom was lightened with the same chelator gel and rinse. After local work, it was going to be beneficial to the paper to wash overall, as there was a significant amount of overall discoloration and the media could withstand that type of treatment. The sheet was blotter washed with adjusted water with a pH of 6.5 and a conductivity of 1 milliSiemen/cm. The blotter wash was repeated two more times and then dried.

For those who are familiar with blotter washing, it is common to have to reposition the artwork once it is on the blotter because the paper expands with moisture. When using adjusted water that is similar in conductivity to the artwork, it simply does not expand and distort as one might expect. If it is expanding less, that also means that the surface is not swelling and changing significantly. It can be inferred that since there is less overall expansion, there may also be less disruption of the media on the surface of the paper. There is still diffusion of soluble acids migrating out of the paper but with much less physical disturbance.

One of Marcel Duchamp's (1887-1968) *Fluttering Hearts*, the print in figures 4 and 5 had been exposed to significant moisture, with heavy cockling and water stains along the lower edge. In addition to overall foxing of varying degrees, the paper also had orange fingerprints in the upper left corner

Fig. 2. Before treatment. Jervis McEntee, *Flowery Tree and Pigs*, 1857.

Fig. 3. After treatment. Jervis McEntee, *Flowery Tree and Pigs*, 1857.

that might be related to the acids or oils on someone's hands. Additionally, there was general darkening around the perimeter of the sheet due to its acidic housing. Because this was a screenprint on a very smooth surface-sized paper, washing was out of the question because of the likelihood that the printing ink would crack and the paper surface would be lost.

Instead, this was treated entirely with local work. The water stains along the bottom edge and the foxing spots were both reduced with a chelator gel, again citric acid at a pH of 6.0 in agarose. The fingerprints and the edge discoloration were treated with isotonic adjusted water on a cotton ball, gently swiping the damp cotton across the paper. An isotonic solution in this case was a pH of 5.5 and conductivity of 1 milliSiemen/cm. Using isotonic water allowed the cotton ball to gently glide across the surface, with no visible surface texture interruptions. If water with a different conductivity were used, such as calcified water, this technique would not work, with the cotton snagging and pilling the surface of the paper. Adjusting the conductivity of the water allowed for less swelling and therefore less wetting and penetration of the paper. After humidification and flattening, the print was significantly improved, and the image itself was never touched. Looking back to the goals for treatment of stains, the media was not affected in any way, and the majority of the original content of the paper was left intact, drawing discoloration away from the surface only where necessary.

Figures 6 and 7 show details of an Agnes Martin (1912-2004) preparatory drawing in black ink on thin, translucent paper. The delicate paper had small, irregularly shaped orange staining in the margin next to and under the ink. The testing for this piece showed that it was very easy to overclean the paper around the stain, as there was a degree of overall discoloration. An overall treatment in this case would qualify as excessive by the standards outlined in the aforementioned goals. The damage was only local and could be treated effectively by local treatment. Discoloration of Martin's papers can often be likened to patina, a characteristic that should be considered heavily before reducing with an overall treatment. Typically, the papers also respond extremely to moisture, expanding strongly, and this risks changes in the relationship between the paper and the media.

Even though pH and conductivity adjusted waters were not used in this circumstance, observing the testing to see how the agarose pellet affected the paper was instructive for designing the treatment. In the end, the stains were reduced with a chelator gel (citric acid at pH 6.0) and an agarose rinse, with 2- to 3-minute applications repeated several times, and drying in between. Quick but incremental applications

Fig. 4. Before treatment detail. Marcel Duchamp, *Fluttering Hearts*, 1961.

reduced the chance of introducing tide lines and reduced surface distortions that might have occurred if the gel were left too long. The amount of moisture ultimately introduced was so low that none of the surrounding paper or media was affected.

Much of David Hammons' (1943-) work on paper is comprised of the body print, in which the artist coats the subject of the print in an oily substance and lays it down on the support, then sprinkles pigment on the oily medium, shaking off the excess. One particular piece (not shown) is composed on black Crescent mat board with a white paper core, and the media is loose white pigment bound to the surface by the oil component. The piece sustained significant direct and

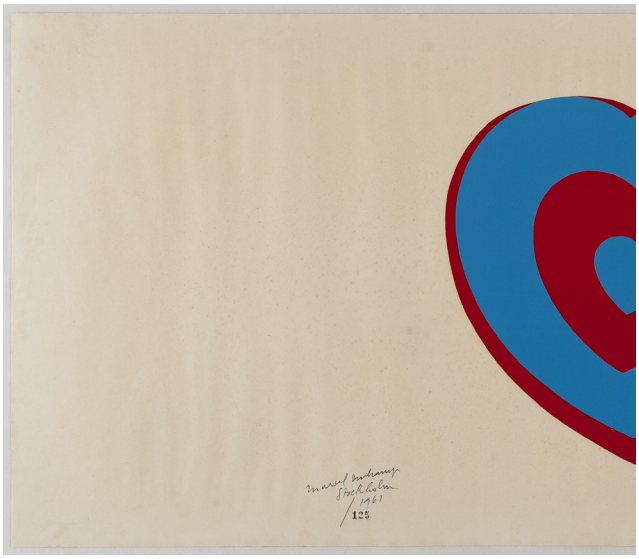

Fig. 5. After treatment, detail. Marcel Duchamp, *Fluttering Hearts*, 1961.

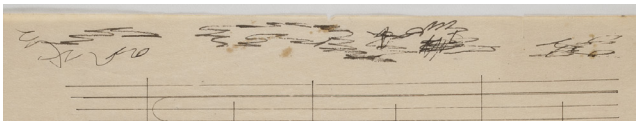

Fig. 6. Before treatment, detail. Agnes Martin, *Untitled*, 1960s.

indirect moisture, with lifting and cockled layers of board, and severe mold staining on the back. The focus of this case study, however, was a drip mark near the left edge that ran horizontally into the figure's face. Since the black paper is only a paper skin adhered to the board, and considering the difficulty of treating black paper without disturbing how light reflects off the surface, there were limited options for treatment. Fortunately, the white staining solubilized with agarose pellets, so the pellets were slowly moved along the drip to reduce the hardest of the lines, trying to diffuse the most obvious. It was important that the dampness of the gel did not lift the paper skin from the core of the board while simultaneously maintaining the surface characteristics of the paper. In a circumstance like this, even if the stain were reduced, a change incurred in the paper texture could be equally as distracting as the white haze from the damage.

In contrast, another Marcel Duchamp print, *Print of Urinal* (not shown), had been treated for a persistent stain that was likely due to exposure to liquid water. The print was on a waterleaf paper that was roughly textured, and the lower third of the print was distinctly discolored, with a tide line at the front of the discoloration visible under UV illumination. The print had been successfully treated aqueously, with staining removed; however, after several months, the stain returned. It was evident that the material that continued to change color was not fully removed, so adjusted waters and chelator gels were used in a more prescriptive manner. The goal was to use chelators to complex mineral components causing bonding of the material in question, and to affect swelling of the paper fibers with adjusted waters in an effort to evacuate as much damaging material as possible.

Because the paper swelled significantly with local moisture, an initial chelator gel of citric acid (pH 6.0) was applied only to the discoloration while the object was in a humidification chamber, rinsing with an agarose gel. Applying gels in a humid environment reduces the chance of physical distortions on reactive paper. The print was then blotter washed with an adjusted water (pH 6.6, 6 milliSiemen/cm), with local brush application of a higher pH water (pH 8.5, 6 milliSiemen/cm). After complete drying, the blotter wash was repeated and dried again. An additional chelator gel of ethylenediaminetetraacetic acid (EDTA) (pH 6.0) was applied

Fig. 7. After treatment, detail. Agnes Martin, *Untitled*, 1960s.

twice more to the discolored area, again in a humidification chamber and rinsing with an agarose gel. After the final drying, the discoloration was significantly reduced and after many months did not reappear.

One of the original intentions of this study was to compare traditional treatments to this newer system of treatment, and evaluate them against one another once they were complete. To do this, test samples were chosen that were older papers similar to what the majority of conservators might see in their practice (fig. 8). They were cut into sections, and the same stain was treated in different ways. After much trial and error, the treatments did not turn out as anticipated. The subtlety that was intended came out a bit clunky, with agarose gels causing tide lines and surface disruptions, and adjusted waters not reducing discoloration as much as expected.

In the end, the issue was probably not the techniques themselves but how they were being used. The authors' studio is accustomed to modern and contemporary art, and their refinement of these methods have been on those types of objects. These were old papers, with old stains, and it is likely that they needed different modifications to the methods being used. Recall the different factors that can be modified with this system: the pH, the conductivity, the delivery method, and modifiers. This leads to a large array of possibilities when combined with the peculiarities of the artwork, so finding the right balance can take some time. Even something as simple as changing the percentage of the agarose from 5% to 7% can have a drastic effect on the control of the treatment.

Another factor to consider is that these methods may not be efficient or effective enough for every treatment. Every once in a while, the chelator gels or the adjusted waters just do not have the ability to affect the damage in an acceptable way. Sometimes a stain needs to be flushed out with solvents on the suction platen. Sometimes they need to be decolorized by a bleach, because no amount of adjusted waters or chelator gels are adequately affecting them. Conceding this point is entirely valid if a more conservative approach proves ineffective.

CONCLUSION

This paper is not about doing away with treatments that paper conservators are used to and know to be effective. The goal has been to show that conservators now have a much wider range of possibilities for the treatment of stains and discoloration on paper, and many can be considered less invasive and more conservative than other options. Recalling Keiko Keyes quote once again, conservators are reminded that they have the responsibility to not only observe the subtleties, but also to use advancements in conservation to refine and control treatments. Adjusted waters and agarose gels allow conservators to work more fluidly on that scale of intervention. The tools can be used to treat artworks that were previously thought too problematic to touch, or to scale back a treatment technique that might feel too aggressive. Knowing the components of the treatment methods is essential to exercising control and recapturing the subtleties of paper.

Fig. 8. Sample papers for different types of treatments.

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