OBSERVATIONS ON SOOT REMOVAL FROM TEXTILES

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ABSTRACT—This paper describes the cleaning of a variety of textiles damaged by soot during a domestic house fire. The characteristics of soot are described, as well as the methods used previously by conservators to clean soot-damaged museum objects. Various methods used in the cleaning of the soot-damaged textiles are described, including nonpolar solvent poultices, aqueous poultices, wet cleaning with solvent and surfactant solutions, and the removal of particulate soot with vacuum cleaners and vulcanized rubber sponges. A brief investigation into the composition and treatment characteristics of vulcanized rubber sponges is also included.

INTRODUCTION

On Christmas Eve 1996, the Higley family of Delaware returned from a church service to find their house on fire. An insufficiently extinguished candle had caused a fire that destroyed much of their house and belongings, and severely damaged what remained. Their neighbor, Gregory Landrey, Director of Conservation at the H. F. duPont Winterthur Museum, offered to help salvage some of their treasured possessions. He felt that this would not only benefit the Higley family, but would also provide a useful learning experience for the students and conservators at the Museum. Among the objects he brought in for treatment were furniture and frames, a collection of Victorian valentine cards, family photographs, and textiles.

The textiles arrived interleaved in newsprint, inside boxes wrapped in plastic. The textiles smelled very strongly of smoke, and were blackened with soot. Some of the textiles were also scorched, and some had candle wax melted into them. A quick inventory revealed around thirty textiles including lace table clothes and doilies, an embroidered picture, sailing pennants and awards, Christmas stockings, souvenir hats, and the Christmas tree angel.

CHARACTERISTICS OF SOOT

The composition and characteristics of soot largely depend on the types of materials that have been burnt. Soot is a mixture of particulate carbon, organic tars, resins, and inorganic materials. Depending on the type of materials burned, and the type of combustion, the tarry component of the soot can be over twenty-five percent by weight of the soot (Gunn et al. 1983). Typically, what we think of as soot (particulate carbon) accounts for less than fifty percent of the weight.

In the Higley family house fire, the burning of synthetics such as carpeting, upholstery, electronic equipment, and paints, resulted in smoke and soot deposits, which were particularly sticky and tenacious. A similar type of soot could be expected from the combustion of materials typically found in museum galleries and storage areas. The analysis of the soot deposited after the 1985 fire at the Huntingdon Art Gallery, which developed in an elevator shaft, revealed a composition of fifty percent elemental carbon and-fifty percent organic carbon—a greasy material (Verheyen 1987). The soot deposited on the Higley family textiles had a slightly acidic pH of 5.8, and this appears to be typical.

The significance of the very sticky soot deposited on the Higley family textiles was that it did not respond well to the vacuum cleaner, and when the particulate matter was removed, the textile below was discolored with yellow and brown staining.

PREVIOUS TREATMENT STRATEGIES

Vacuuming has always been advocated as a first step in the removal of soot from artifacts. This method was found to be highly effective in the cleaning of the objects damaged during the 1990 fire at the Saskatchewan Museum of Natural History (Spafford and Graham 1993). A micro-adapted vacuum nozzle was found to be the most effective way of removing soot from the fur and feathers of the natural history specimens. The vacuuming was followed by dry cleaning with eraser-type products, and wiping with aqueous and solvent-based systems. Ethanol, and a one percent solution of Vulpex in trichlorethylene, were found to be the most effective materials for removing the remaining residues, depending on the type of material being cleaned and the degree of soot coverage.

Vacuuming was again the most effective treatment for the textiles damaged in 1980 due to a furnace puff back at the History Museum at the Museums at Stony Brook (Gray Armstrong et al. 1981). Due largely to the more particulate nature of the soot generated from the furnace (though it did have an oily component), and the fact that objects far away from the furnace outlet had only a very light dusting of soot, this was the only treatment carried out on the majority of the textiles damaged in this incident. The textiles on display in the galleries were the most damaged, and these were wetcleaned in the conventional manner where possible. Textiles that could not be wetcleaned were referred to commercial dry cleaners, though it was found that the effectiveness of the dry cleaning was largely proportionate to the amount of agitation possible.

The textiles damaged in the Huntingdon Gallery fire were first vacuumed without any surface contact at all. Large, complex objects such as upholstered chairs and carpets, were then treated with rice-hull ash and Freon solvent poultices. Textiles that could be washed were washed in a conventional way (Verheyen 1987).

Vulcanized rubber sponges (or dry-chem sponges as they are sometimes called) are widely used in the commercial fire and flood business for cleaning all kinds of surfaces. This type of sponge was used after the Saskatchewan Museum fire to clean dioramas and other smooth surfaces (Spafford and Graham 1993). They were also used by the staff of the Jenkins Publishing Company in Austin, Texas following a disastrous fire in their rare book room. The sponges were used with success to clean bindings, and proved especially effective on smooth cloth, though the sponges were found to leave a residue and smell (Etherington 1986).

It has been reported that earlier brands of dry-chem sponges were chemically impregnated, hence the name. This may account for the residue and smell experienced by the staff of the Jenkins Publishing Company (Mowery 1991).

CLEANING THE HIGLEY FAMILY TEXTILES

Preliminary testing of the Higley family textiles showed that vacuuming, even at high suction, was going to be of little use in removing the particulate soot. Vulcanized rubber sponges were tested next with gratifying results. These had been found to be most useful in cleaning the soot from the valentine card collection salvaged from the Higley's house (Price 1997). The brand of sponge used to clean the valentine cards, "Dry Magic Wallpaper Cleaner", was tested on one of the textiles and was found to remove the majority of the surface soot. The sponges were gently wiped over the surface, using a clean sponge surface as soon as one side was dirty. The sponges can be washed in plain water, and reused when dry, though they tend not to pick up soot as effectively after washing. It is therefore a good idea to cut the sponges into small flat rectangles to provide the largest surface area possible for cleaning.

Once the surface soot had been reduced, the residue below was tested with a variety of solvents. Those tried were: tetrachloroethylene; xylene; Stoddard Solvent; 50/50 acetone/2 percent Orvus WA Paste in deionized water; acetone; ethanol; 2 percent Orvus in deionized water; 0.2 percent Triton XL-80N in deionized water; and deionized water. Acetone and Stoddard Solvent were most effective in moving the yellow/brown residue from the textile. The 50:50 Acetone/2 percent Orvus in deionized water combination was also effective in removing the yellowing, and removed more of the particulate soot. Ethanol was also effective, but less so than other combinations. Both tetrachloroethylene and xylene were quite effective in moving the yellow/brown staining, but were felt to be too noxious to be used for such large scale cleaning as the Higley textiles would require. The surfactant and water combinations were not effective in moving the yellow/brown staining, but did show signs of reducing the particulate soot further.

A general strategy was developed for the cleaning. First, particulate soot would be reduced using the vulcanized rubber sponges. After removing the soot, the level of discoloration in the textile would be assessed, and depending on the degree of discoloration in the textile, it would be treated with a sequence of solvents. Proceeding from nonpolar to polar, the solvents would be applied in a variety of ways. The final step would be to wet clean the textile if possible.

CELLULOSIC TEXTILES WITH LITTLE SOOT

Three identical doilies were treated first to evaluate the treatment of cellulosic textiles with little soot accumulation, as many of the Higley family textiles fell into this category. The circular lacy doilies were made of crocheted heavy-weight cotton. All had light soot accumulation on one side only, with clear patches where objects had stood on them during the fire. Two were initially treated. The first was wiped all over with a vulcanized rubber sponge, and then wetcleaned inside a fume hood in a solution of 50:50 acetone/one percent Orvus in deionized water. Solvent and surfactant mixture do not foam very much at first, due to the depressing effect of the solvent on the efficiency of the surfactant, but as the solvent evaporates from the mixture the surfactant becomes more effective. The doily was agitated with sponges and a stiff brush during soaking. The doily was then rinsed in deionized water and dried beneath a clean cotton muslin cloth. The second doily was wiped with the sponge, wetcleaned with one percent Orvus in deionized water only, rinsed, and dried. The doily that had been washed in Orvus solution only was very slightly more yellow after drying, and so the third doily was cleaned with the 50:50 acetone/Orvus solution.

A rectangular piece of cotton with a batik design of a head was treated in a similar way to the doilies. Particulate soot was removed from the surface with a vulcanized rubber sponge. Less soot was removed from this textile in this way than any of the other textiles treated. The soot seemed to be particularly stuck to the surface, possibly due to wax residue remaining from the batik process. Dyes used in the batik design proved to be fugitive to acetone, and so a 25:75 ethanol/1 percent Orvus in deionized water solution was used to wetclean this textile, and proved to be very effective.

CELLULOSIC TEXTILES HEAVILY COATED WITH SOOT

Two identical round, embroidered cotton doilies with a heavy coating of soot were treated in slightly different ways to evaluate the effectiveness of the treatments. One was wiped with the vulcanized rubber sponge and then laid in a shallow photographic tray lined with blotting paper. Stoddard solvent was applied to the top of the textile with an eyedropper, blotter was laid on top, and all layers were weighted down with Plexiglas blocks to keep close contact between the textile and the blotters. The whole package was then placed in the fume hood and left until the Stoddard Solvent had evaporated. The blotters were considerably yellowed when removed. The textile was then washed in 50:50 acetone/one percent Orvus in deionized water, rinsed and dried. The second doily was treated in the same way except for the omission of the Stoddard Solvent and blotting-paper poultice. The results in both cases were good, but with a slight yellowness noted on the doily that was not treated with Stoddard Solvent.

A rectangular cotton cloth edged with fine bobbin lace was one of the most heavily soot-coated objects treated. The piece was totally blackened with soot except for very bright spots where objects had stood on the surface during the fire. One edge of the bobbin lace was also scorched and partially burnt, and there were tidelines from the water used to extinguish the fire. The lace was in fragile condition generally with some small tears and losses. In the interests of saving as much of the Higley's possessions as possible, this textile was given a more thorough and aggressive treatment.

The top surface of the doily was wiped with vulcanized rubber sponges, which had little effect. The textile was then treated with Stoddard Solvent in the manner described above. It was then washed in 50:50 acetone/one percent Orvus in deionized water, though with no agitation of the delicate bobbin-lace edges. After rinsing and drying, it became clear that the bobbin lace was still quite heavily soiled with soot, though the central cotton portion of the textile was quite clean. The textile was laid on a sheet of Mylar on the countertop. A thin layer of cotton wadding soaked in one percent Orvus in deionized water was laid over the soiled bobbin lace, and then covered with a thick layer of cotton. The textile was allowed to dry overnight. It was then removed and rinsed again in deionized water. The cotton and Orvus-solution poultice was very effective in removing the soot trapped in the bobbin lace. The areas of scorching in the lace edging were treated locally with a three percent solution of hydrogen peroxide. This effectively minimized the jarring appearance of the scorching. The torn lace was then repaired with fine cotton thread.

SYNTHETIC TEXTILES

On the whole, synthetic textiles responded poorly to treatment. Two nylon yachting pennants with moderate soot coverage and yellow staining proved the most difficult to treat. The particulate soot was fairly easy to remove using vulcanized rubber sponges and mechanical action, while cleaning the pennants with solvents and then solvent and surfactant mixtures. One pennant was treated with a Stoddard Solvent and blotting-paper poultice prior to wetcleaning. A solution of 50:50 acetone/0.2 percent Triton XL–80N was used to wetclean both of the pennants. However, the yellow/brown understaining did not respond well to any of the solvents used, and some staining remained despite all efforts to remove it.

A synthetic lace tablecloth with only a very light dusting of soot responded in a similar way to the pennants: the particulate soot was easily removed by washing, but the yellow staining below remained. Clear circles where objects had stood on top of the tablecloth during the fire could still be seen after treatment, though the textile did not appear to be badly soot-damaged prior to treatment.

WOOLEN TEXTILES

Three wool felt hats were treated by wiping them with vulcanized rubber sponges, and then rolling cotton swabs moistened in Stoddard Solvent over them. Much of the particulate soot was removed using this treatment, though the hats still smelled strongly of smoke. In an attempt to minimize the smell, the hats were wrapped in activated charcoal cloth and left for several days. This had limited success.

Commercial dry cleaning was recommended for one of the hats, an English naval cap, which remained soiled after treatment.

RESULTS OF TREATMENT

The results of the treatments were mixed. Generally, cellulosic textiles responded very well to cleaning: particulate soot was easily removed with mechanical means, and the yellow staining could be removed if treated rather aggressively with solvents. Many of the treatment steps require more mechanical action than would be usual when treating delicate museum objects.

Poulticing, though time consuming, was effective in removing both soot and staining, and would probably be a better way to approach the cleaning of delicate textiles. Poultices of solvents and of surfactant solutions were tried on the Higley textiles, and both were effective.

Wools and synthetics proved harder to clean. The fibers seemed to have more of an affinity with tarry and oily components of the soot, and efforts to remove the staining using a variety of methods and materials met with limited success.

No silk items were included in the textiles salvaged from the fire. Given the chemical similarity between silk and nylon one could expect that silk might respond in a similar manner to the nylon sailing pennants.

Objects that could not be wetcleaned in some way retained a strong smell of smoke after treatment, and while this does not effect the aesthetic value of the object too badly, it does indicate that products of the fire were still present.

The treatment of composite objects, such as the family Christmas stockings (which were made from recycled antique cotton quilts trimmed with synthetic lace, ribbon, and metal bells) also had mixed results. The cotton quilt body of the stocking responded well to cleaning, but the synthetic ribbon and lace trimming did not, and so the overall appearance of the stocking after treatment was disappointing. Another composite object, the Christmas tree angel, had to be partially disassembled to allow cleaning of the textile portions without destroying painted paper elements and metallic trimming.

THE TIME FACTOR IN CLEANING SOOT-DAMAGED TEXTILES

The majority of the textiles were cleaned five months after the fire, in May and June of 1997. A number of textiles were not cleaned at that time, but were left in the original cardboard boxes, interleaved with newsprint, until April 1998—some sixteen months after the fire. While the particulate soot was as easy to remove after sixteen months as it was after five months, the yellow/brown staining below the soot was not. In the more heavily soot-coated textiles, this understaining could not be entirely removed after sixteen months using the same methods used earlier.

TESTING OF THE VULCANIZED RUBBER SPONGES

Vulcanized rubber sponges proved invaluable in the preliminary cleaning of the Higley family textiles, by removing particulate soot from all kinds of surfaces without leaving any visible residue. Most of the textiles treated with the sponges were consequently washed in some way, and so the concern about residue from the sponges was less of a concern. However, some of the Higley family textiles treated with these sponges were not subsequently wetcleaned and so I felt it would be useful to investigate some of the properties of these sponges.

Previous research carried out at CCI had shown the sponges used in the Saskatchewan Museum of Natural History fire cleanup, and other brands commonly available in Canada, to be composed of vulcanized cis–1, 4–polyisoprene, with calcium carbonate fillers. They also contained a trace amount of oil, probably from the manufacturing process, and the trace elements S, Al, Si, Fe, Zn, and Na (Moffatt 1986, 1991, and 1992).

Six brands of vulcanized rubber sponges available from conservation supply houses in the United States were tested at the Museum of Fine Arts, Boston, using FTIR microspectroscopy. All brands were found to be composed of poly(isoprene), 1, 4–cis, with a calcium carbonate filler in almost identical proportions.

The concern for conservators using these sponges is the sulfur used to vulcanize the poly(isoprene) and make it into a solid material rather than a sticky liquid. The question of whether the sponges crumble when used, or leave behind a sulfur-containing residue, was investigated next.

Following the guidelines laid out for Oddy testing for off-gassing of materials, the possibility of leaving behind residue when using vulcanized rubber sponges was tested for in the following way. Three strips of washed cotton muslin were cut from the same piece of fabric. One strip was put aside as a control and the other two were wiped ten times on each side with a "Wonder Sponge" brand vulcanized rubber sponge. One of the treated strips was then vacuumed carefully on both sides using a dental aspirator. Three small squares were cut from the center of each of the strips and assigned a random number. Each of the pieces was placed in a glass container with a small vial of deionized water and three small metal coupons, one each of copper, silver and lead. The glass containers were stoppered, labeled with their randomly assigned number, and placed in an oven at 60°C for twenty-eight days.

The tarnishing found on all of the samples was very slight, and some of the metal coupons were not tarnished at all. The metal coupons were evaluated by four independent observers who ranked them from least tarnished to most tarnished. No difference was noted in the tarnishing of the coupons in the untreated group compared with the group of samples that had been wiped with the sponge and then vacuumed. The independent observers consistently reported more tarnishing on the metal coupons in the group of samples that had been wiped with the sponge but not vacuumed. This would seem to indicate that vacuuming the samples removes particles that cause the coupons to tarnish. It must be remembered that the Oddy test is not a sensitive test, and that the sample group was small.

Three other strips of washed cotton muslin were cut from a different piece of fabric. One piece was set aside and the other two were wiped ten times on both sides with a "Wonder Sponge" brand vulcanized rubber sponge. One of the treated samples was carefully vacuumed with a dental aspirator. A square was cut from the center of each piece and they were labeled as 'untreated', 'treated', and 'treated and vacuumed'. Each sample was examined using a Scanning Electron Microscope, and no difference could be seen between the untreated sample and the two treated samples. No residue of a particulate nature could be seen on any of the samples.

CONCLUSIONS

In the light of the investigations mentioned in this paper, and the successful removal of soot from the Higley family textiles, vulcanized rubber sponges appear to be a good choice in the cleaning of soot-covered but sturdy textiles, particularly when vacuuming makes little impact on the soot.

The use of nonpolar solvent poultices in conjunction with wetcleaning using polar solvent and surfactant solutions proved successful in the cleaning of even heavily soot-covered cellulosic textiles. While particulate soot could be removed from synthetic materials and wool using similar methods, the tar and organic resins deposited with the soot resisted removal by all methods tried.

Textiles that were not cleaned shortly after the fire proved much more difficult to clean after having been left for a year. Particulate soot could be removed, but the tar and organic resins in the soot could not be completely removed. This suggests that soot-damaged articles be cleaned soon after a fire if permanent damage is to be avoided.

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SOURCES OF MATERIALS

Vulcanized rubber sponges:

Absorbene "Dirt Eraser": Conservation Resources, 8000–H Forbes Pl., Springfield, Virginia 22151; 800–634–6932; and Gaylord Bros., Box 4901, Syracuse, NY13221–4901; 800–634–6307.

The Gonzo Corporation "Wonder Sponge": Hardware stores, and bed-and-bath emporiums.

Sparkle Plenty "Dry Magic Wallpaper Cleaner": hardware stores.

No Brand Name: Talas, 68 Broadway, New York, NY 10012; 212–219–0770; Conservation Support Systems, 924 West Pedregosa Street, Santa Barbara, CA 93101; 800–482–6299; and University Products, P.O. Box 101, 517 Main Street, Holyoke, MA 01041; 800–532–9281.

Activated charcoal cloth: Charcoal Cloth Ltd., East Wing, Bridgwater Lodge, 160 Bridge Road, Maidenhead, Berkshire, SL6 8DG, U.K.

Orvus WA Paste: Talas, 568 Broadway, New York, NY 10012; 212–219–0770.

Triton XL 80–N: Conservation Support Systems, 924 West Pedregosa Street, Santa Barbara, CA 93101; 800–482–6299.

Stoddard Solvent, acetone, ethanol, xylene and tetrachloroethylene: all available from Fisher Scientific and other chemical supply houses.

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