An Evaluation of Nd:YAG Laser-Cleaned Basketry in Comparison with Commonly Used Methods

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Abstract. While in storage and on exhibition, baskets can accumulate dirt that is aesthetically undesirable and even harmful. The nature of the woven structure, as well as the porosity of organic materials, causes difficulty in the removal of accumulated dirt. This paper presents results from a study of basket-cleaning methods focusing on how Nd:YAG laser-cleaned samples compare to those cleaned by more commonly used methods. Cleaning tests were performed on stem, bark, and root sample materials in order to examine the effects of cleaning on a variety of plant materials that are commonly encountered with basketry. Photography, optical microscopy, and scanning electron microscopy were used to document and compare the effectiveness and drawbacks of these methods. The results indicated that plant materials with protective cuticle layers can be effectively cleaned using low-tech methods and such fibers would not greatly benefit from laser cleaning. Materials without protective cuticle layers are more sensitive to mechanical cleaning and could possibly be more safely cleaned using lasers.

1. Introduction

The problem of surface dirt on basketry has been approached from many different angles due to the difficulty of cleaning. The nature of the woven structure and the fibrous quality of plant materials complicate the cleaning process. Dirt easily becomes imbedded in the rough, uneven surfaces. A study to compare cleaning methods was undertaken to address the scarcity of published information on the cleaning of basketry [1]. This study examined several commonly used cleaning methods including a brush and vacuum, cotton swabs lightly dampened with deionized water, and Groomstick [2]. Lasers were included in the study as a possible new cleaning tool because they have been used successfully for cleaning other organic materials. In this paper, we will present the findings of the laser component of this study in comparison with the most effective commonly used methods. It is important to remember that the irreversible nature of cleaning necessitates a careful approach to treatment, particularly with basketry materials as they often have evidence of ethnographic use. Any residue that could be associated with use should not be disturbed during the removal of post-collection dirt and grime. The ability of cleaning methods to leave residue undisturbed was not investigated.

Criteria for evaluating the appropriateness of a cleaning method include: (1) the effectiveness of dirt removal, (2) damage to fibers and the weave structure, and (3) the retention/deposition of residues from cleaning materials. As our study confirms, the first two criteria are related to the characteristics of the basket, including the type of fiber used, the structure of the weave, and condition of the artifact.

The influence of a basket material's morphology on the success of cleaning cannot be understated. Basketry materials usually fall into one of four categories –roots, stems, leaves, or bark. Stems, roots, and leaves all have an outer layer of epidermal cells which protect their internal structure. These layers have openings called stomata that regulate air and vapor transmission. In addition, the epidermal layers on stems and leaves produce a waxy cuticle layer that covers the structure, (Fig. 1). The cuticle is not comprised of one homogeneous layer but several layers of differing chemical compositions [3]. The cuticle layers help to reflect ultraviolet and infrared radiation, as well as waterproof the plant. If present after processing, these protective layers can help prevent damage to the fiber during cleaning and handling.

Inner bark on the other hand is found within a woody stem. Its location within the stem eliminates the need for protective layers. When the root and bark fibers are pulled apart during processing, the cells are split longitudinally, leaving a vulnerable structure with no outer protective cells.

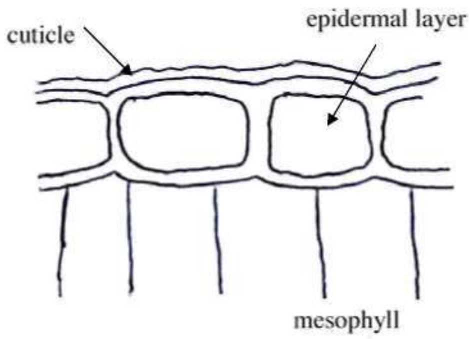

Fig.1. Diagram of stem epidermis (based on Florian 1990: 8).

2. Experimental Methods

2.1 Sample Materials and Preparation

This paper discusses controlled irradiation with lasers, along with the three most commonly used cleaning methods: brushing and vacuuming, swabbing with cotton lightly dampened with deionized water, and swabbing with Groomstick.

Three different plant materials were sampled for cleaning tests with six different methods [4]. An unidentified stem material, cedar bark, and spruce root were chosen to represent the variety of plant structures encountered on artifacts.

Fig. 2. Stem sample

Fig. 3. Cedar bark sample

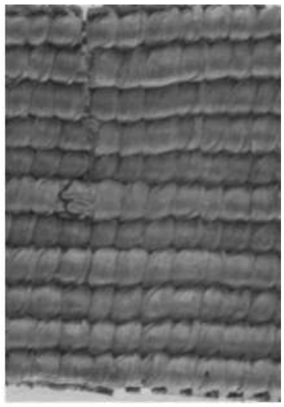

Fig. 4. Spruce root sample

The first sample set was taken from an Italian basket constructed of an unknown stem material (Fig. 2). The fibers appeared to be in excellent condition, with the exception of some areas that appeared more fibrous in texture possibly indicating fiber damage. These areas were avoided during sampling. The other samples were taken from artifacts belonging to the Buffalo State College Art Conservation Department’s study collection. Both of these artifacts originate from tribes from the northwest coast of North America. One object was a woven mat constructed of the black, orange-red, and tan-colored inner bark from a cedar tree (Fig.3). The other basket consisted of twined spruce root (Fig. 4). Both the spruce root and cedar bark artifacts showed some wear and brittleness. The types and degree of soiling varied between the three types of sample materials. The stem material had a heavy layer of grey particulate. The spruce root had a darkened appearance that appeared to be imbedded soiling, along with some light grey particulate soiling on the surface. The cedar bark had very little surface soiling, particularly for the purposes of this study. It was artificially soiled by mixing dirt collected from artifact storage areas and carbon black pigment. This mixture was dusted onto the lightly dampened surface of the sample set.

Three samples measuring approximately 3.18 by 3.18 cm were used for each cleaning method for each material to allow for the observation of variations. In addition, a control sample was used for each sample set. An effort was made to choose samples with similar degrees of soiling. An additional control was used for the stem material. The two-layer construction of the basket maintained an unsoiled woven surface on the interior sides of each layer. A sample was taken from this area for comparison with the uncleaned sample.

2.2 Cleaning Procedures

The brush and vacuum technique involved lightly brushing the samples with a fan brush while directing particulate into a vacuum nozzle. This technique was performed for 10 seconds on each of the three sample types. Swabs were dampened with deionized water and blotted to remove the excess. The swabs were rolled across the surface or individual elements using the swab tip to reach into crevices when needed. This technique was performed for 35 seconds on the cedar bark and stem samples and 25 seconds on the spruce root samples. A 2.54 by 0.48 cm section of Groomstick was applied to the end of a bamboo skewer. The Groomstick was rolled across the surface for 25 seconds on each of the three materials. The laser cleaning was performed using a Lynton Lasers Phoenix Q-switched Nd:YAG laser at the infrared wavelength of 1064 nm. Fluence was determined by dividing pulse energy by the area of the beam (estimated using carbon paper). A pulse rate of 2 Hz was maintained for all cleaning tests. All samples were cleaned using fluences of 0.39, 0.45, and 0.56 J/cm^2. Additional testing was performed at the fluences of 0.20, 0.29, and 0.35 J/cm^2 for the stem material and 0.17, 0.35, and 0.42 J/cm^2 for the spruce root material. No further testing was done on the cedar bark material due to a limited supply of sample material.

2.3 Documentation and Analysis

Samples were documented before and after cleaning using a Nikon D-100 digital camera. Optical microscopy and scanning electron microscopy were used on the control samples and one of the three samples from each cleaning method and material.

3. Cleaning Results

3.1 Stem

All four cleaning methods were visually effective in reducing soiling. Brushing and vacuuming produced the most even cleaning because the brush was able to reach the deep interstices of the weave structure (Fig.6). Water-dampened swabs were unable to achieve the same effect but revealed more of the original sheen than other methods. Groomstick removed a moderate amount of dirt. The laser-cleaned samples significantly reduced soiling over the entire surface, including the deep interstices, but left an overall dull appearance on some of the samples. Photomacrographs taken before and after treatment show only minor fiber disturbances with the commonly used cleaning methods and no change with the laser-cleaned samples. Scanning electron microscopy showed the brush and vacuum and the water-dampened swabs to be slightly abrasive to the cuticle surface, while there was little damage with the Groomstick-cleaned sample. Damage was very apparent with laser cleaning at the higher fluences of 0.39, 0.45, and 0.56 J/cm^2. At the highest fluence, the cuticle was largely ablated leaving the underlying cell walls exposed, (Fig. 7). This damage was also apparent with the 0.45 J/cm^2 sample. The cuticle layer of the 0.39 J/cm^2 sample appeared to have been partially reduced. The samples cleaned with a fluence below 0.35 J/cm^2 had larger amounts of dirt remaining but also have intact cuticle layers (Fig. 8).

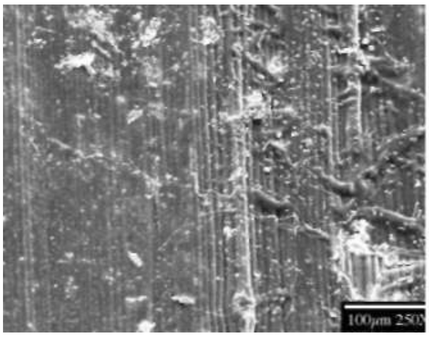

Fig. 5. Stem control sample

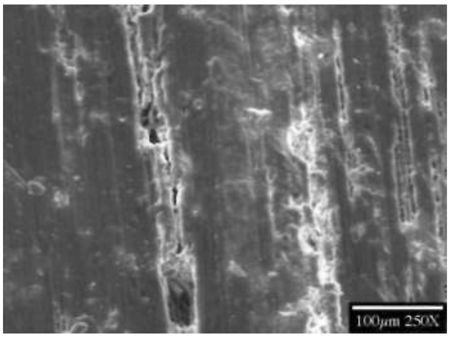

Fig. 6. Water-cleaned stem

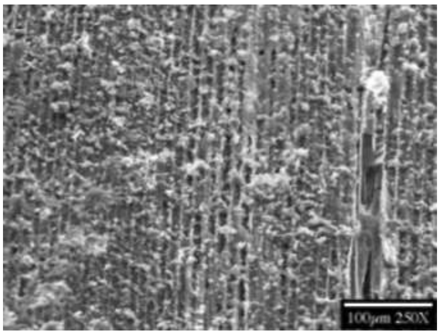

Fig 7. Laser-cleaned stem (0.56 J/cm^2)

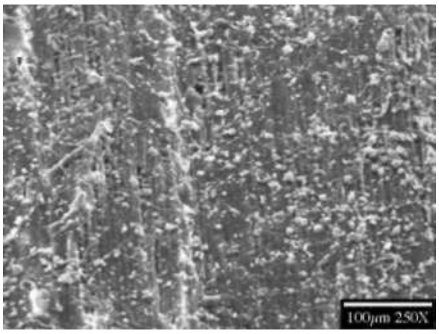

Fig 8. Laser-cleaned stem (0.35 J/cm^2)

3.2 Cedar Bark

The three low-tech methods for dirt removal were only marginally effective. Photomacrographs showed damage to the sample surfaces in the form of removed or damaged fibers. Groomstick was clearly damaging and should not be used with this type of material. As with the stem material, brushing and vacuuming removed more of the dirt trapped between the woven elements, while the water-dampened swabs revealed more fiber sheen. Lasers were clearly seen as less damaging on this type of material. Loose and damaged fibers were left undisturbed and there was an overall reduction in surface dirt. SEM analysis of the cleaned samples revealed the brush and vacuum method to be the least damaging of the more common cleaning methods, (Fig. 10), while water-dampened swabs were clearly the most damaging due to the removal of the delicate cell walls, (Fig. 11). The laser-cleaned samples at the highest fluence of 0.56 J/cm^2 showed some disturbance and removal of the cell walls, (Fig. 12). Damage, if any, at the lower fluences of 0.39 and 0.45 J/cm^2 was difficult to distinguish from the original condition of the fibers. It is likely that no laser-induced damage occurred at the 0.39 J/cm^2 cleaned sample. The lack of extra sample material prevented further testing.

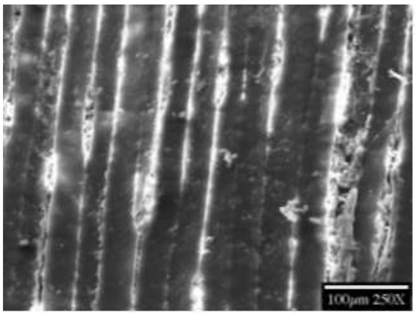

Fig. 9. Cedar bark control

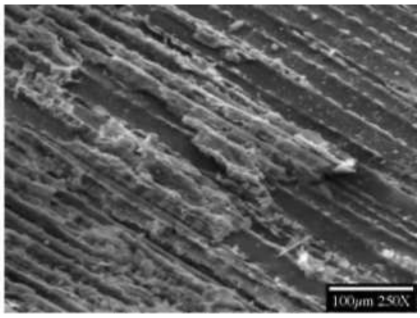

Fig. 10. Brush and vacuum cleaned bark

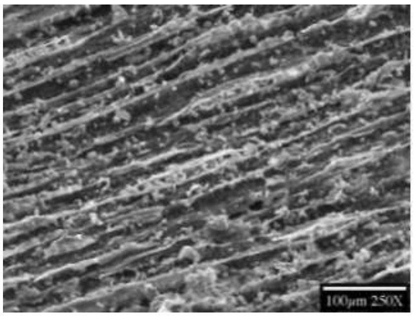

Fig. 11. Water-cleaned bark

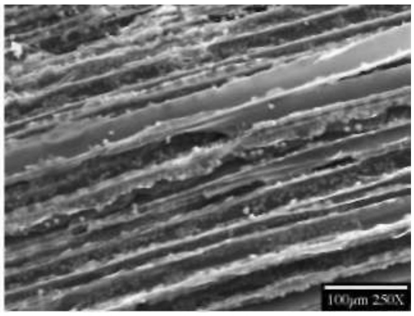

Fig. 12. Laser-cleaned bark (0.56 J/cm^2)

3.3 Spruce Root

Of the low-tech methods, brushing and vacuuming was the only one to produce visually acceptable results. Although swabbing with water-dampened cotton swabs or Groomstick removed some light surface dirt, the pressure produced by these methods was too great. The laser-cleaned samples were the only ones to show any significant reduction in dirt, likely due to the imbedded nature of the soiling. SEM analysis was difficult to interpret with this material due to the complex structure and apparent damage on the control sample. The results were inconclusive.

4. Conclusions

This study suggests that the appropriate cleaning method for a basket depends on the type of fiber used for construction. Materials that have protective cuticle layers can be cleaned with a wider variety of techniques than materials without cuticle layers. Commonly used methods such as a brushing and vacuuming and swabbing with water-dampened cotton, or a combination of both are sufficiently effective on materials with protective cuticle layers. This study established a damage threshold for lasers on materials with cuticle layers and those without. Lasers could be beneficial on materials without protective cuticle layers such as spruce root and cedar bark materials. These more fragile materials are easily damaged during cleaning with more traditional materials. The loosely bound fibers of cedar bark are easily lifted and disturbed using traditional methods. Dirt also becomes easily embedded in fibrous materials such as cedar bark and spruce root making them difficult to clean. In addition, the weave structure and condition of many baskets constructed of these types of fragile materials makes the pressure of swab cleaning impractical, while lasers do not involve physical contact or pressure. In conclusion, while lasers can provide visibly effective cleaning, cellular damage that is not visible to the unaided eye could occur. Assuming that appropriate fluences are chosen, laser cleaning may be useful for cleaning problematic basket materials and structures, especially since low-tech methods appear to cause comparatively more damage.

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References

1 Ruth Norton's section on cleaning in *The Conservation of Artifacts from Plant Materials* is an extremely useful guide on the topic. M. E. Florian, D. P. Kronkright, and R. E. Norton, J. Paul Getty Trust, Los Angeles, 1990

2 Groomstick is vulcanized cis-1,4-polyisoprene with titanium dioxide used as a filler. It is described as a molecular trap by the manufacturer and has a very tacky quality. Available from Talas, New York; http://www.talasonline.com

3 P. J. Holloway, "Structure and histochemistry of plant cuticular membranes: an overview," in *The Plant Cuticle*, Edited by D. F. Cutler, K. L. Alvin, and C. E. Price, Linnean Society Symposium Series, No. 10, 1980

4 The two less effective methods not discussed in this paper were the use of a Magic Rub polyvinyl chloride eraser in combination with vacuuming and Smoke Off sponges, a polyisoprene sponge marketed for the removal of soot. Available from Talas, New York; http://www.talasonline.com