Laser cleaning of a Navajo wool blanket by Nd:Yag

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While laser cleaning is increasingly used in art restoration, there are relatively few applications on textiles. We demonstrate effective laser cleaning of soot-like deposits on a *Navajo Phase I Chief Blanket*. The cleaning protocol was derived from colorimetric and mechanical testing of reference churro wool cleaned with the second harmonic (532 nm) fundamental (1064 nm), and included samples subjected to accelerated light and thermal aging.

The privately owned (churro) wool blanket dates to 1840-1850. Its classic pattern features broad alternating bands of undyed white and dark brown, punctuated with narrow indigo-dyed bands. Large areas of gray contamination were evident throughout white bands on both sides. Given the minute amount of material required for a visible color change on a substrate of transparent fibers, the contaminant could not be determined by Raman spectroscopy or FTIR. Reflectance spectroscopy revealed the difference in reflectance between white and gray areas to be flat and uniform throughout the near-UV, visible, and near-IR. This is consistent with carbonaceous deposits, which were deemed the most likely contaminants. Laser cleaning was consequently selected to remove the deposits.

Laser cleaning tests were performed on reference material of woven Navajo churro wool. Kremer furnace black was dispersed by sonication in DDI water and airbrushed uniformly onto reference samples until peak reflectivity was reduced by ≈50%. The soiled areas were laser cleaned by a Nd:Yag laser at 5 Hz. Tested parameters included wavelength (532 nm and 1064 nm), pretreatment (moistening with DDI or not), number of pulses per laser spot area (4, 40, and 400), and flux (6, 36, and 66 MW/cm^2 at 532 nm and 7.5, 29, and 50 MW/cm^2 at 1064 nm). Accelerated light and thermal aging tests of cleaned and uncleaned reference samples were performed to gauge the potential long-term impact of the treatment parameters on the color and tensile properties of the wool fibers. Light aging was performed at 100 kLux for two weeks in an Atlas ci35 fadeometer. Thermal aging was performed at 60 Celsius and 75% RH for three weeks in a Caron 7000-33-1 environmental chamber, approximating 60 years of aging at 20 Celsius and 65% RH. The laser-cleaned and control sample's measured reflectance curves and single-fiber yield strengths were within statistical error of each other both before and after accelerated aging. Pre-wetting reduced cleaning effectiveness in all cases. Irradiation at 1064 nm left a red-brown stain that appeared to be a byproduct of the excited soot.

Irradiation at 532 nm, 35 MW/cm^2 and 40-400 pulses provided excellent soot removal with no detectable optical or mechanical changes in the wool fibers. The results provided confidence to apply these parameters to the soiled white (transparent) wool bands of the artwork. This soiling was successfully, though irregularly, reduced overall. Several techniques were developed to enhance the Navajo blanket's cleaning, including tensioning of narrow sections of the soiled bands over small shaped jigs to "expand" the tightly woven structure. Approximately 300 hours were needed including developing the manipulation protocols, but time should be significantly reduced for future treatments.