NASA/TM—2001-211326

Treatment and Analysis of a Paint Chip From "Water Lilies" a Fire Damaged Monet

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December 2001

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Prepared for the
2001 Fall Meeting
sponsored by the Materials Research Society
Boston, Massachusetts, November 26–30, 2001

National Aeronautics and
Space Administration

Glenn Research Center

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Acknowledgments

The authors would like to thank Winstone Wells, Dianne Modestini, and Molly March of the New York University Conservation Center for the Institute of Fine Arts for the opportunity to conduct tests on the paint chip from the fire damaged Monet "Water Lilies" painting and for many helpful discussions.

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TREATMENT AND ANALYSIS OF A PAINT CHIP FROM "WATER LILIES" A FIRE DAMAGED MONET

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ABSTRACT

A museum fire in 1958 severely damaged a Monet "Water Lilies" (1916–1926) painting that was on display. The surface of the painting is very dark with areas of blistering and charring. Over the years, traditional techniques have been found to be ineffective at removal of the soot and char from the surface. The painting, which is now in the care of the New York University (NYU) Conservation Center of the Institute of Fine Arts, was the subject of a study to determine if atomic oxygen treatment could remove the soot and char without damaging the fragile painting underneath. For test purposes, a small chip of paint was removed from the edge of the painting by a conservator at NYU and supplied to NASA Glenn Research Center for atomic oxygen treatment and analysis. The diffuse spectral reflectance, at three locations on the paint chip, was monitored at intervals during the atomic oxygen treatment process. Photo documentation of the chip during treatment was also performed. The color contrast was calculated from the spectral reflectance data as a function of treatment duration. Results of the testing indicated that the contrast improved as a result of the treatment, and the differentiation of colors on the surface was significantly improved. Soot and char could be removed without visibly affecting the gross surface features such as impasto areas. These results indicate the feasibility for the treatment of the "Water Lilies" painting.

INTRODUCTION

Research on atomic oxygen as a treatment technique for art applications started through inquiries by the Conservation Department of the Cleveland Museum of Art and discussions with many conservators representing museums and private studios worldwide. The primary interest has been as a tool for removing fire damage from the surface of fine art.

Atomic oxygen is present in Earth's atmosphere at altitudes where satellites typically orbit. It has been shown to react chemically with surfaces or deposits that contain carbon [1,2]. The reaction converts the carbon to volatile species such as carbon monoxide. Materials already in a high oxidation state such as the metal oxides used in many paint pigments are typically not affected by atomic oxygen. Ground based facilities for producing atomic oxygen have been developed for testing the materials that are used to construct low Earth orbiting satellites [3,4]. These facilities dissociate molecular oxygen into atomic oxygen by radio frequency, microwave radiation, or electron bombardment typically under a partial vacuum between 0.027 and 20 Pa (2×10^{-4} to 0.15 torr) depending on the oxygen dissociation process used.

Atomic oxygen is of interest for cleaning fine art because the process is in the gas phase, therefore there is no mechanical contact, and the reaction is confined to the surface, which

reduces the risk of damaging the underlying paint or canvas. The atomic oxygen cleaning technique has been used to effectively remove soot from canvas, acrylic gesso, a watercolor, and several oil paintings [5,6,7].

Conservators at New York University (NYU) Conservation Center of the Institute of Fine Arts were interested in determining if atomic oxygen could remove soot and char from a fragile "Water Lilies" painting that was damaged in a museum fire in 1958. Edges of the painting have been the object of many conservation treatment investigations over the years. However, no acceptable restoration process has been identified to date. This study investigates the viability of atomic oxygen treatment for removing soot and char from a paint chip removed from the edge of the "Water Lilies" painting.

APPARATUS AND PROCEDURE

The irregularly shaped paint chip, roughly 1.25 cm by 1 cm, was mounted onto a sheet of aluminum 5.08×7.62×0.1524 cm using Elmer's white glue. The chip was mounted so that the aluminum could be used as a support to keep the chip intact during transfer from treatment to analysis, and also to act as a reference guide for lining up the sample for viewing in the microscope and making diffuse reflectance measurements. The mount and adhesive also protected the backside of the chip from exposure to atomic oxygen.

Examination and photo-documentation of the paint chip prior to, during and after atomic oxygen treatment was performed using an Olympus SZH Stereo Zoom Microscope and camera. Initially the chip was viewed and photographed with the microscope, and then three areas were selected for monitoring through the treatment process based on uniformity of the damage over a 0.3175 cm diameter area (approximate illumination and detection area of the spectrophotometer), and flatness. The coordinates of each area (A, B, and C), as shown in Figure 1, were recorded using a Boeckeler X-Y translation system on the microscope stage so that the same area could be returned to for examination during the treatment process.

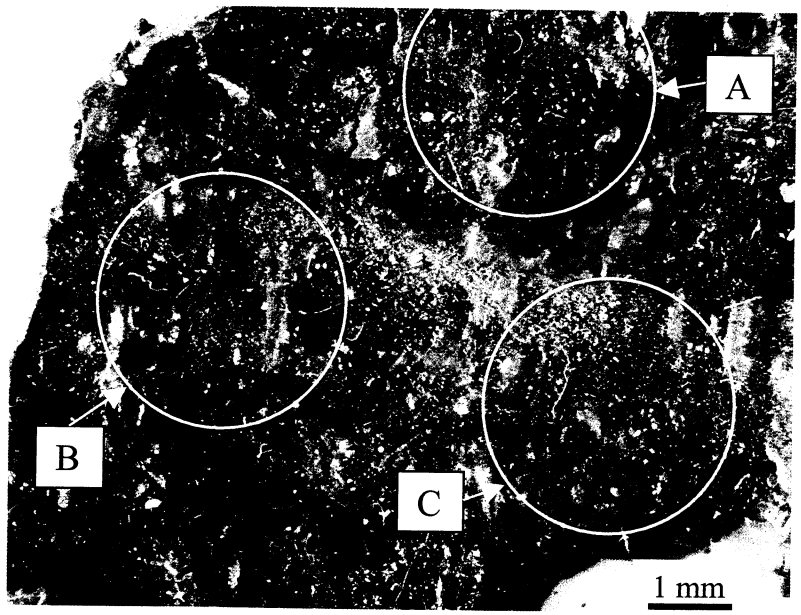

Figure 1. Monet "Water Lilies" paint chip showing sampling locations

Atomic oxygen treatment was performed in a small vacuum plasma chamber (SPI Plasma Prep II) operated on air at pressures of 12.7 to 16 Pa (95 to 120 mTorr). The air was dissociated into atomic oxygen using radio frequency radiation. The mounted paint chip was placed inside the vacuum chamber on top of glass slides for treatment.

Diffuse reflectance measurements, at each of the selected coordinates, was made prior to, at intervals during, and after atomic oxygen treatment using an Ocean Optics Spectrophotometer. In order to keep the spectrophotometer aligned with each of the coordinates, the translation system was removed from the microscope stage and mounted onto a stage that supported the spectrophotometer light source and detector in a fixed position. These measurements were made in order to quantify changes in the surface of the chip with regard to the shape of the spectral curve (color), as well as the color contrast as a function of treatment time. The diffuse reflectance from the surface was measured over the wavelength range of 450 to 650 nm because it covers the majority of the spectrum over which the human eye is sensitive [8]. Contrast was determined by observation of the wavelengths that gave the highest and lowest reflectance levels with exposure and then comparing the difference between the reflectance values at these wavelengths as a function of treatment. The result is an indication of the color contrast within the measured area due to treatment. The end point of the treatment process is indicated by contrast values that change little and the shape of the diffuse reflectance as a function of wavelength curve remaining fairly stable with increasing treatment time.

DISCUSSION

The diffuse reflectance as a function of wavelength at location A on the paint chip is shown in Figure 2. The plot is similar to that obtained in area C. The plot shows an initial reflectance that was low and very flat which is indicative of a uniformly dark gray surface. As the chip was treated with atomic oxygen, the reflectance began to increase overall and exhibit a greater increase in reflectance in the region of approximately 450 to 510 nm, which is the blue region of the spectrum. Area B lightened a little but did not show as marked a change in the shape of the curve, which may be due to the central area of the measurement not being as soot covered as areas A and C initially. This can be seen in Figure 3, a plot of the contrast for each of the three areas as a function of treatment dose or fluence, which is represented by the number of atoms that arrived at a square centimeter of the paint chip over the duration of the exposure. With treatment, sample location A and C contrast values generally increased to a limiting value, while that for location B remained fairly constant.

After treatment was concluded, a Grumbacher Acrylic Picture Varnish was sprayed on the chip in a light mist. The varnish serves to prevent the pigment, which is now loosely bound to the surface after treatment, from being inadvertently removed. It also acts as a fill for the charred binder that was removed and causes the paint colors to become more saturated. This is represented by a greater differentiation between diffuse reflectance measurements obtained over specific segments of the wavelength region and can result in either a decrease or increase in contrast depending on the angle at which the reflectance is measured. Pigment particles that are loosely bound tend to reflect in more directions with respect to the surface by scattering the incoming light, while addition of a binder between the particles reduces the scatter and makes the reflection from the surface more specular.

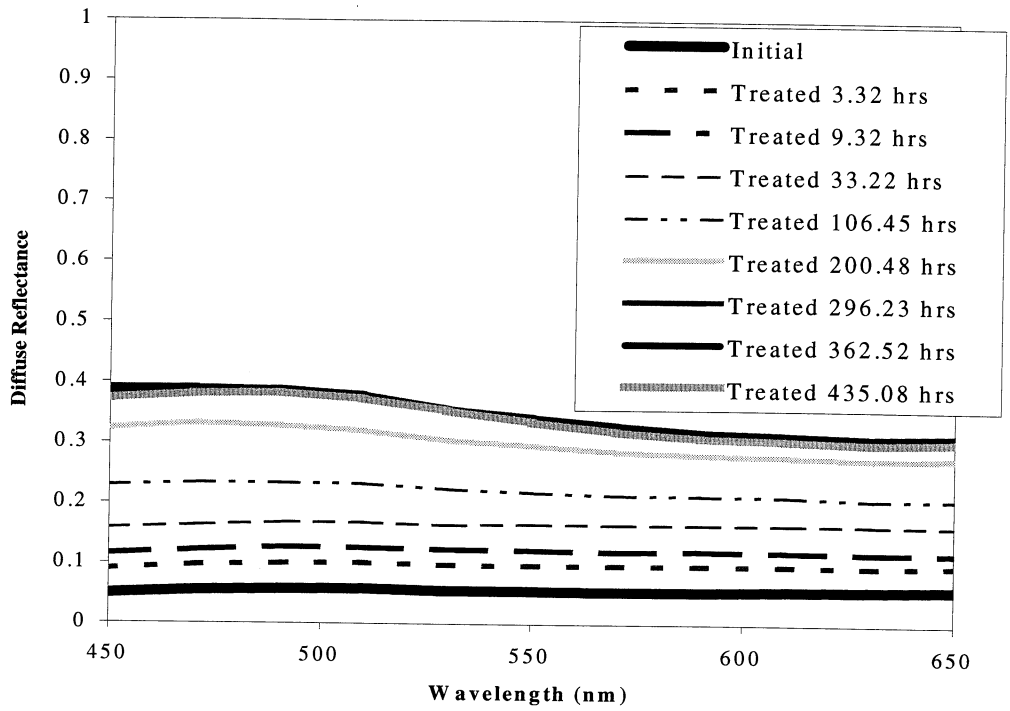

Figure 2. Diffuse Spectral Reflectance for selected intervals of atomic oxygen treatment at sample location A on the Monet "Water Lilies" paint chip

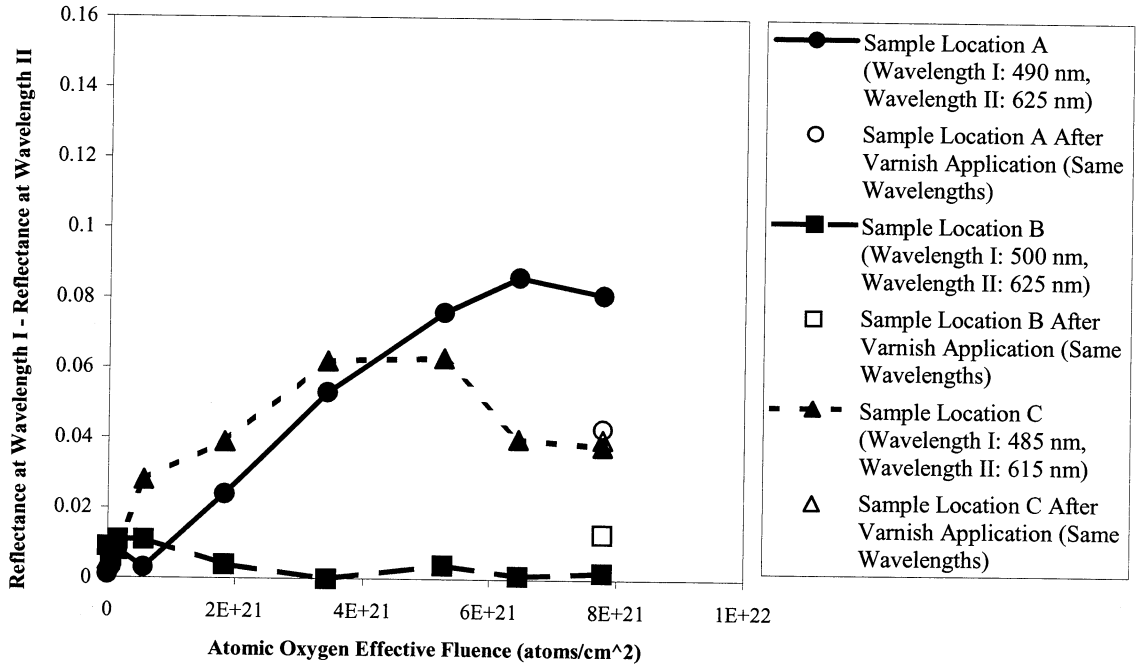

Figure 3. Contrast at selected locations on the Monet "Water Lilies" paint chip as a function of atomic oxygen treatment

Figure 4 contains microscope photographs of the paint chip showing the region surrounding and including location A, prior to treatment, after atomic oxygen treatment, and after treatment and application of varnish. The atomic oxygen treatment was able to effectively remove the soot from the surface of the chip and expose bright blue and green pigments, whose colors were further saturated by addition of the acrylic varnish. As can be observed from the photographs, surface features and overall texture of the paint remained undisturbed through the treatment process.

These results indicate the feasibility for the treatment of the Monet "Water Lilies" painting. It appears that atomic oxygen treatment can remove the soot and char and expose the pigments without greatly altering the surface features that are present. If the paint on the surface flowed due to the heat of the fire, this would not be affected by atomic oxygen treatment so it is unclear whether or not a full recovery of the painting is possible. The treatment of the chip was performed in a small radio frequency plasma chamber, however, larger paintings have been treated in the past in a larger radio frequency plasma chamber that could accommodate the Monet painting. Careful observation and recording of the process by both conservators and scientists would be needed to enable the full painting to be treated safely.

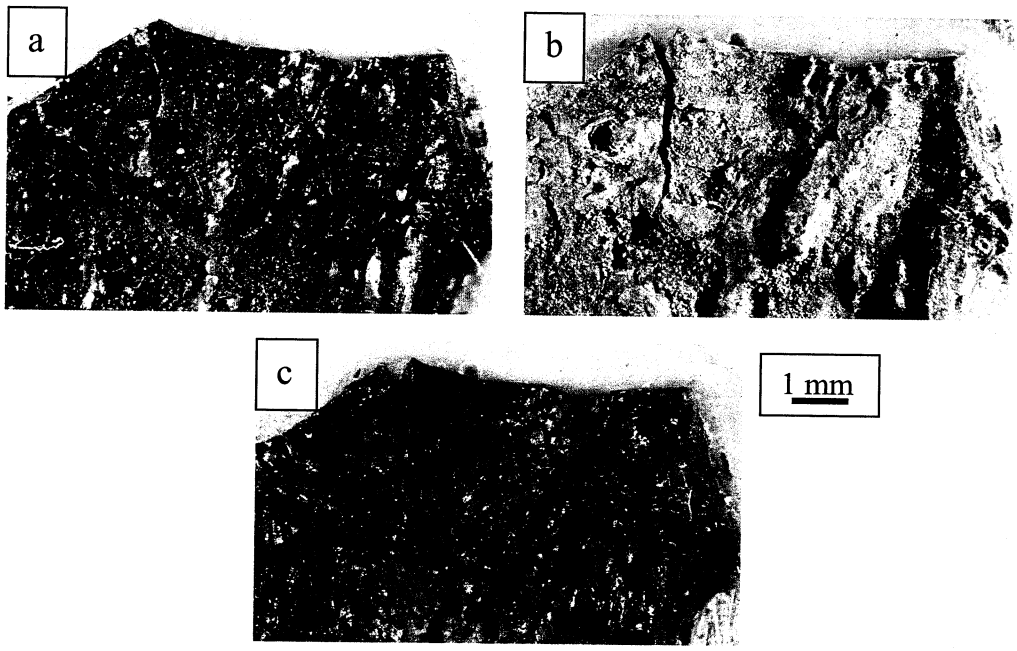

Figure 4. Region surrounding and including location A: a. prior to treatment, b. after atomic oxygen treatment, c. after atomic oxygen treatment and application of acrylic varnish

CONCLUSIONS

Results of atomic oxygen treatment of a chip from the edge of a fire damaged Monet "Water Lilies" painting indicate that atomic oxygen was able to effectively remove soot from the surface and expose the underlying paint pigments. Increases in diffuse reflectance and contrast were observed on selected areas of the paint chip during treatment. Microscope observation also indicated that surface features and overall texture were preserved through the treatment process. With careful documentation and treatment by conservators and scientists, it appears feasible that the soot and char can be effectively removed from the Monet "Water Lilies" painting.

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1. AGENCY USE ONLY (*Leave blank*)

2. REPORT DATE
December 2001

3. REPORT TYPE AND DATES COVERED
Technical Memorandum

4. TITLE AND SUBTITLE
Treatment and Analysis of a Paint Chip From "Water Lilies" a Fire Damaged Monet

5. FUNDING NUMBERS
WU–755–A4–13–00

6. AUTHOR(S)
Sharon K.R. Miller, Bruce A. Banks, and Greg Tollis

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
John H. Glenn Research Center at Lewis Field
Cleveland, Ohio 44135–3191

8. PERFORMING ORGANIZATION REPORT NUMBER
E–13135

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
National Aeronautics and Space Administration
Washington, DC 20546–0001

10. SPONSORING/MONITORING AGENCY REPORT NUMBER
NASA TM—2001-211326

11. SUPPLEMENTARY NOTES
Prepared for the 2001 Fall Meeting sponsored by the Materials Research Society, Boston, Massachusetts, November 26–30, 2001. Sharon K.R. Miller and Bruce A. Banks, NASA Glenn Research Center; and Greg Tollis, Cleveland State University, Cleveland, Ohio 44115. Responsible person, Sharon K.R. Miller, organization code 5480, 216–433–2219.

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14. SUBJECT TERMS
Monatomic gases; Oxygen; Restoration; Arts; Fire damage

15. NUMBER OF PAGES
12

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT
Unclassified

18. SECURITY CLASSIFICATION OF THIS PAGE
Unclassified

19. SECURITY CLASSIFICATION OF ABSTRACT
Unclassified

20. LIMITATION OF ABSTRACT