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Atmospheric Monatomic Oxygen System For Non-Contact Nanoscale Cleaning Of Vandalized 20th - 21st Century Modern And Contemporary Artworks

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Atmospheric Monatomic Oxygen System For Non-Contact Nanoscale Cleaning Of Vandalized 20th - 21st Century Modern And Contemporary Artworks

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INTRODUCTION

1 The paper discusses defacement materials used in diverse acts of vandalism against the modern and contemporary art and stresses the need for a safe and effective methodology to treat sensitive and fragile unprotected surfaces of 20th and 21st century artworks that frequently are vandalized using carbon based materials. The paper proposes the proven concept for a nanoscale cleaning mechanism based on monoatomic oxygen, which does not require any physical contact with the surface or any liquid phase cleaning medium.

BACKgROUND

2 The instability and unpredictable aging of 20th-21st century cultural heritage materials make the work of conservation, display, transport and storage a challenge. Among the many threats to modern and contemporary art, soiling and deposition of unwanted materials is of particular concern, due to use of nontraditional materials and techniques, and the common practice of creating extremely fragile surfaces free of protective coatings. In this context, accidental defacement or vandalism may be particularly devastating. As the cultural and monetary values rise, 20th – 21st century artworks,

increasingly become targets of vandalism, which may be motivated by aesthetic and ideological rebellion, but also be driven by diverse psychological, emotional disorders, or personal reactions to the artworks content, context or monetary value. Acts of vandalism are very frequent during armed conflicts or art crimes, when cultural heritage assets are destroyed because of ideological reasons or damaged by reckless handling or storage. In 2004, two Edvard Munch paintings, the "Madonna" (1894-95) and "The Scream" (1910), arguably Norway's greatest cultural treasure were stolen from the Munch Museum in a daytime armed raid. The paintings were brutally ripped out of their frames shattering the glazing, and when recovered by the Norwegian police in 2006 bore damages from this vandalous crime: shattered glass fragments stuck in a fragile porous paint, torn canvas, scratches, loose paint, soiling and water damage on "The Scream".

3 Some of the most deleterious art vandalism results from defacement of highly sensitive surfaces by deposition of carbon-based compounds such as soot, hydrocarbons or other organic materials. In this context, fire-damage, smoke and soot have particularly devastating and instantaneous effects. The British Fire Protection Association (FPA) estimated 63% of fires in British and American museums and libraries between 1986 and 1991 were the result of arson [Baril 1998]. Other defacements may involve deposition of materials such as lipstick, grease or other hydrocarbons, ballpoint pen, colored food, drinks, graffiti inks, spray paint and more. A high profile example is Andy Warhol's "Bathtub" (1961), which was kissed with red lipstick in the middle of the white, unprotected porous paint surface. During a 2007 exhibition in Avignon, yet another lipstick kiss permanently damaged a monochrome white surface of the minimalist painting "Phaedrus" (1977) by Cy Twombly. During the legal proceedings, the perpetrator testified that she was "overcome with passion" in front of the painting. In 1977, a similar passionate *raptus* occurred at the Oxford Museum of Modern Art, resulting in a lipstick kiss on the white monochrome painting "Untitled" (1977) by Jo Baer and the list could be continued with the viral trend of leaving kisses on the white porous tombstone of Oscar Wilde in Paris and other cases. Although lipstick appears to be popular among the "art-loving" vandals, this is only one of many defacement materials. In July 2016 at Nuremberg's Neues Museum, a visitor used a ballpoint pen to "complete" Arthur Köpcke's "Reading-Work Piece" (1965). The crossword-inspired piece features the phrase "insert words", which the visitor took literally and began filling in the blanks. In 1994, Yoko Ono's "Part Painting/A Circle" (1977) installation, which consists of 24 white panels crossed with a large black stripe as an endless horizon was defaced by a visitor, who "responded" to nearby quote from Ono, "No one can tell you not to touch the art," by adding his own bold line with a red marker. In 1996 at MOMA NY, a Canadian art student who claimed that the "commodification and canonization of art objects as a sacred cultural history makes him sick" vandalized Piet Mondrian's "Composition in White, Black and Red" (1936) by vomiting colored food over the painting in order to add "color and texture" and to bring the viewer back to reality that exists outside the museums. More recently at the Tate Modern in 2012, a similar "rebellion" drove a vandal to deface Mark Rothko's "Black on Maroon" (1958) with an inscription written with a highly staining "Molotow Coversall Cocktail" graffiti ink [Ormsby et al 2014] and the list could continue.

CHALLENGES REMOVING DEFACEMENT MATERIALS FROM SENSITIVE 20^{TH}-21^{ST} CENTURY CULTURAL HERITAGE OBJECTS

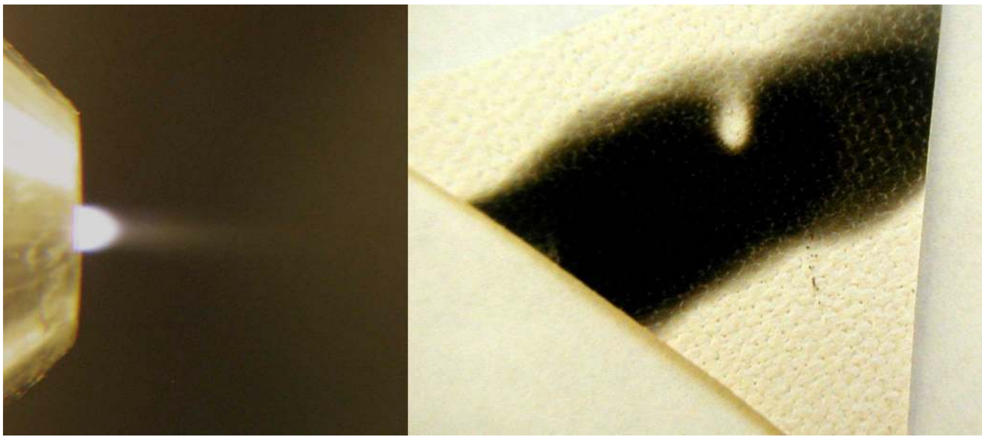
4 When an unprotected and porous paint surface, textile, plaster, plastics or exotic modern art materials is defaced using lipstick, colored foods, drinks, grease, ballpoint pen, marker, graffiti paint, soot or other carbon-based / organic compounds, any cleaning attempt may become a daunting challenge for conservators since most cleaning techniques require physical contact with the artwork and/or use of liquid phase medium. The range of modern art materials is limitless and any contact cleaning may become impossible when the object is composed of extremely fragile, porous, heterogeneous, fugitive exotic art materials, such as chewing gum, salt crystals, blood, butterfly wings and more. Conventional "dry" or "wet" cleaning methods tend to transport the organic soiling further into the porous substrate, where soiling remains permanently trapped, acting as an initiation point for further deterioration and changing the surface morphology and appearance. In contrast to the well-established protocols for the cleaning of pre-20th century objects, the removal of soiling and unwanted materials from modern and contemporary artworks remains a challenge. Many unprotected sensitive surfaces are intolerant of any liquid phase cleaning medium or mechanical action, whereas inadequate cleaning methods risk to irreversibly disrupt the aesthetic, monetary and cultural value of the artwork. Limited conservation technologies often lead to an impasse in the treatment choices. When the defacement cannot be treated, highly valuable objects will remain off-display for years and may be considered as permanently lost.

5 How should these ultra-delicate 20th century art objects be cleaned, if by simply touching them, they could permanently be altered?

NON-CONTACT ATOMIC OXYGEN CLEANING MECHANISM AND ITS POTENTIAL FOR TREATING SENSITIVE 20^{TH}-21^{ST} CENTURY CULTURAL HERITAGE OBJECTS

6 Fragile modern and contemporary surfaces would greatly benefit from methods that do not require any physical contact and liquid phase medium. At present such methods (laser, plasma, $C0_2$ snow, and ultrasound) are used on robust and stable materials, but have limited use treating sensitive surfaces. Laser and plasma ablation tools lack selectivity, in some cases require liquid interface medium and lead to excessive heat transfer that pose limitations to their use on sensitive modern materials, confirmed by the discolored appearance of some laser or plasma cleaned surfaces. An alternative groundbreaking solution may be found in the development of monoatomic oxygen technology. While the list of materials employed by vandals can be very broad, the discussed cases illustrate how frequently carbon based compounds are used to deface artworks. These compounds could be effectively removed in a non-contact nanoscale process using monoatomic oxygen, which does not require any mechanical action or any liquid phase cleaning medium.

Fig. 1 Detail of experimental atmospheric atomic oxygen apparatus nozzle with atomic oxygen effluent



Atomic oxygen cleaning test removing soot from canvas primed with white acrylic paint.
Photo: NASA

7 Monoatomic oxygen (O) is one of the three species of oxygen besides diatomic oxygen (O_2) and ozone (O_3). Atomic oxygen is predominant in the Earth's thermosphere, where it is produced naturally through the photo-dissociation of molecular oxygen by UV radiation, but is extremely short lived on the ground. To date, most atomic oxygen research has been limited to NASA space and laboratory testing of the spacecraft materials and development of atomic oxygen facilities in simulated space environment vacuum chambers (2-5). However, in the processes experimented by B. Banks and S. Miller, atomic oxygen effluent has also been produced at normal atmospheric pressures, introducing a new potential application for art conservation.

Fig. 2 Detail of defaced A. Warhol painting (right)

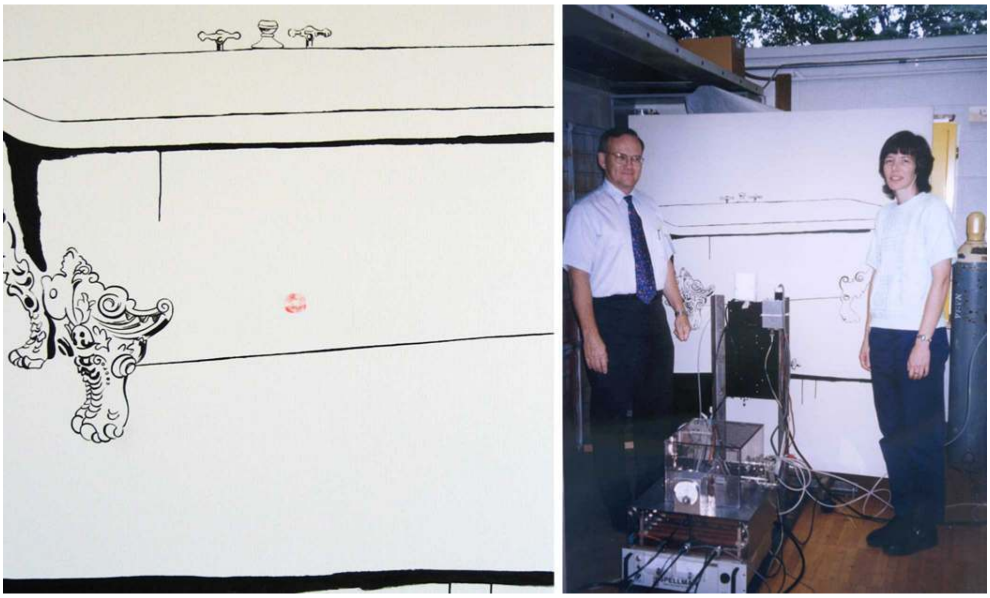
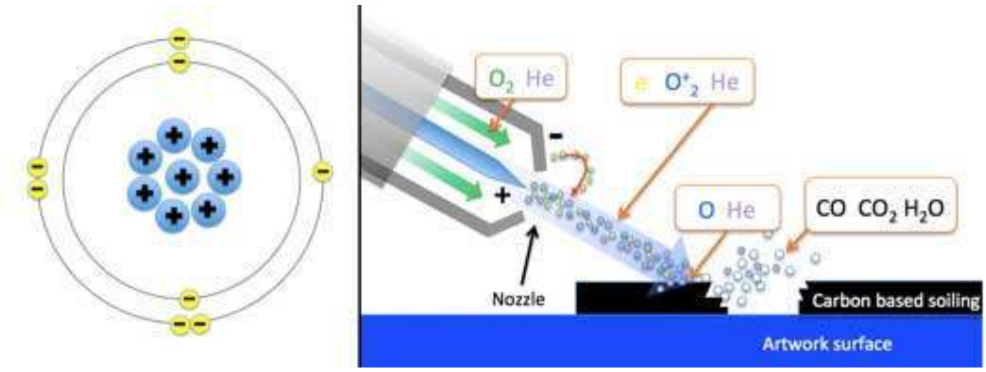


Photo: "Bathtub" during treatment using experimental atomic oxygen generator constructed by B. Banks and S. Rutledge at NASA John Glenn Research Center (left).
Photo: NASA - courtesy by Andy Warhol Foundation

8 The high degree of reactivity of atomic oxygen requires its production and use to occur simultaneously. Among the methods to produce atomic oxygen artificially, electric arc dissociation is the safest and most feasible process for the specific art conservation application.

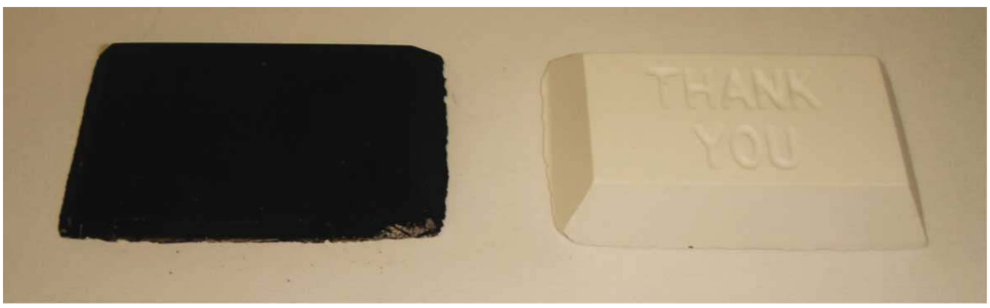
Fig. 3 Oxygen atom



Nucleus 8 protons; inner shell 2 electrons, outer shell 6 electrons (left).
Photo Markevicius, T.

9 In the proposed concept cleaning process, the monatomic stream is formed by flowing a mixture of O2 in an inert noble gas (Ar, He or other) through a high voltage, low current DC arc, which, will form O at atmospheric pressure through electron impact dissociation ($e^- + O_2 \rightarrow e^- + 2O$), dissociative attachment ($e^- + O_2 \rightarrow O + O$), or by reaction with He metastable (He(23) + O2 → He+2O). The targeted AO mechanism involves the ionization of O_2 by energetic electrons and the release of the electrons from the ionization process. The cathode spot where electrons originate from on the annulus orifice injects electrons into the arc, causing ionization of O_2. However, the O^+_2 ions heading toward the negative electrode are too massive to make the bend and are propelled towards the artwork surface, while the electrons move toward the positive electrode. Inert He gas is used to minimize the gas recombination and to transport the newly created O^+_2 ions to the surface under treatment. The impact dissociation of O^+_2 occurs and two atoms separate. The O^+_2 ions are neutralized by extraction of an Auger electron from the target surface under treatment. The bulk or surface conductivity can supply electrons back to the treated surface after the Auger electron is extracted or there are sufficient electrons in the effluent that allow the artwork to maintain a near neutral surface.

Fig 4. Application of atomic oxygen removing candle soot from plaster



The sample was cleaned in a vacuum chamber using radiofrequency plasma dissociation method.
Photo: NASA

10 Upon hitting the surface, the effluent of atomic oxygen reacts instantly with the first carbon-based materials in its way - carbon/organic soiling - producing volatile by-products such as CO, CO_2 and H_2O vapors, efficiently removing carbon-based soiling, soot, hydrocarbons and most organic unwanted materials through ablation. In the proposed mechanism atomic oxygen interacts only with the surface, does not dwell in the bulk of material and removes carbonaceous soiling materials at room temperature, and in normal ambient conditions exists for a few milliseconds, which allows for residue-free cleaning at the nanoscale. In this targeted atmospheric atomic oxygen cleaning mechanism, the active cleaning material is solely atomic oxygen, which differs substantially from radiofrequency plasma dissociation method that require vacuum environment and that of plasma "torches" where the energized effluent is a "soup" of diverse reactive species. In the atmospheric mechanism atomic oxygen is not energized and is free of vacuum ultraviolet (VUV) radiation, ozone and the "soup" of hazardous reactive species present in plasma cleaning, which is also associated with excessive heat transfer and surface soiling from sputtered metal particles emanating from the plasma "torch" electrodes.

TESTING AND PRACTICAL APPLICATION OF ATOMIC OXYGEN IN CONSERVATION

11 The first application of atomic oxygen in art conservation took place in the late 1990s in response to the unwanted lipstick smudge on Andy Warhol's "Bathtub", where contact/ solvent-based cleaning methods could not be used. In response to this "lipstick challenge" B. Banks and S. Miller applied NASA atomic oxygen technology for the first time in an actual conservation treatment (6). Testing on mockups was conducted first to remove several lipstick types from white primed canvas.

Fig 5. Non-contact atomic oxygen cleaning

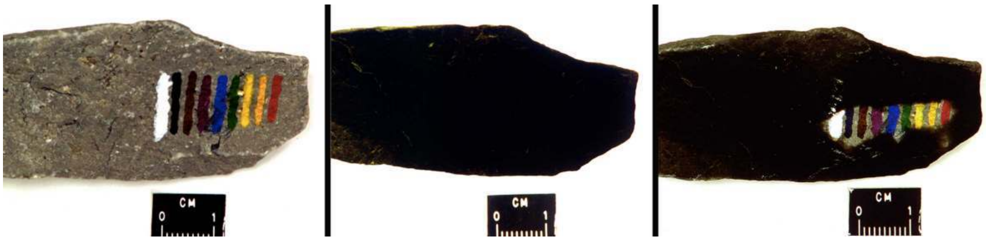
NON-CONTACT ATOMIC OXYGEN CLEANING TEST ON CANVAS PRIMED WITH ACRYLIC TITANIUM WHITE PAINT: HALF OF LIPSTICK SMUDGE (LEFT) REMOVED USING ATOMIC OXYGEN WITHOUT ANY CHANGES TO THE ORIGINAL MATERIAL.

12 Circular atomic oxygen cleaning tests on the imprint of a lower lip (right).

13 Photo: NASA

14 The target red lipstick smudge measured 3.3 cm x 3.5 cm. Partial solvent cleaning of the lipstick (acetone 1: 3 mineral spirits), taking care not to drive solubilized lipstick into the porous substrate, in order to reduce the duration of the atomic oxygen treatment. The residual lipstick was successfully removed using the atomic oxygen effluent. Atomic oxygen also removed a thin layer of soiling, exposing a lighter surface, which was subsequently toned by inpainting.

Fig. 6. Atomic oxygen test

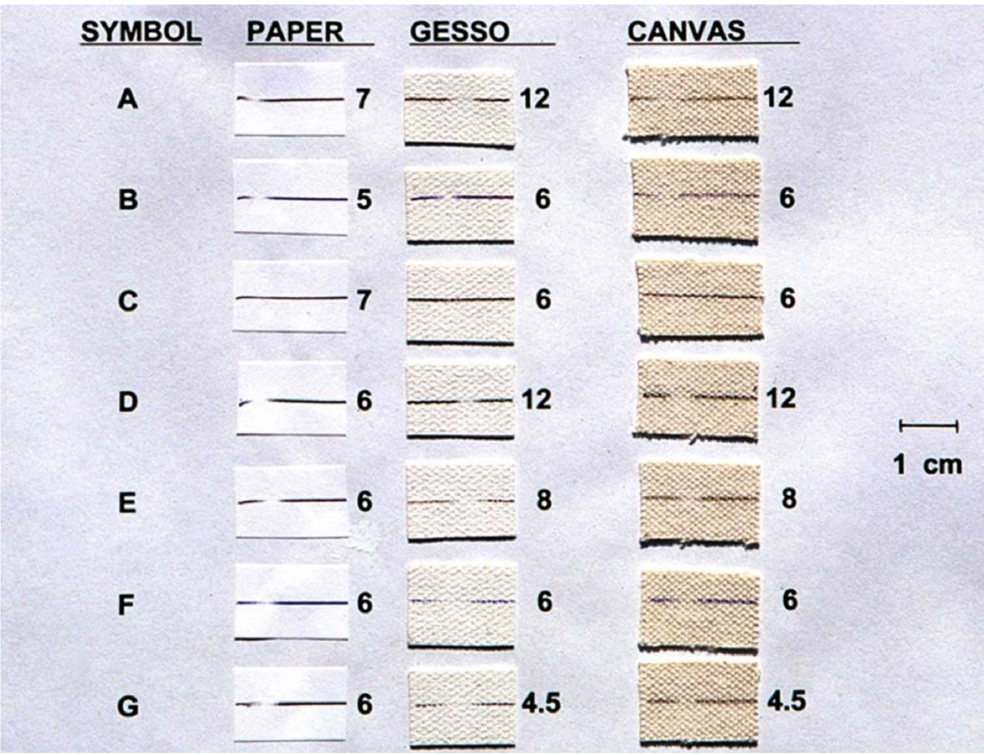


Atomic oxygen test cleaning greasy soot from painted stone samples.

PHOTO: NASA

15 Initial atomic oxygen experimentation for conservation application was carried out at NASA in the Large Area Atomic Oxygen Exposure Facility using radiofrequency plasma dissociation, a table-top radiofrequency plasma asher, and an experimental atmospheric atomic oxygen source prototype using electric arc dissociation on sample artistic media such as modern oil and acrylic paints, watercolors, paper, plaster, limestone, ivory, textile to remove soot, carbonized varnish and inks used in a ballpoint pen and several types of markers. Atomic oxygen removed most of the inks with a 4.5 - 12 min exposure. Black ink from a Sanford Sharpie® permanent marker was the only ink that was not removed. This is probably a result of inorganic pigment components that are not affected by atomic oxygen. In other cases atomic oxygen effectively removed soiling and undesired unwanted materials from plaster, canvas and other tested materials (7-10). Initial testing indicates that atomic oxygen could be used on a broad range of modern and contemporary surfaces, but since universal treatment methods do not exist in conservation, it is reasonable to expect that it may not be suited for every situation or material.

Fig 7. Atomic oxygen testing on paper, primed and raw canvas removing ballpen and marker's inks



A) American Hardpoint felt tip black Eberhard Faber marker B) Waterbury felt tip blue marker C) Stanford Sharpie permanent black marker D) Paper Mate Flair felt tip black marker E) Bic Round Stick ball-point, medium black F) Scripto Stick Pen, ballpoint, medium black G) Paper Mate Rubberstik ballpoint, medium black (left).

PHOTO: NASA

16 Further development of atomic oxygen technology for art conservation requires advancement of the apparatus design and atmospheric oxygen production and spatial dispersion method, and an assessment of the effects of atomic oxygen cleaning through the characterization of the physical, chemical and optical properties of 20th -21st century art materials treated with atomic oxygen to obtain an in depth understanding of the molecular and nanoscale mechanism and characterization of atomic oxygen cleaning effects on 20th -21st century art materials.

CONCLUSIONS

17 In conclusion, atmospheric monoatomic oxygen has an exceptional unexplored potential to form the basis for a new non-contact and non-solvent cleaning technology to remove carbon-based soiling, soot, hydrocarbons and most organic unwanted materials from soiled sensitive surfaces. In contrast to water or solvents that propagate and dwell in the artwork, the action of extremely short-lived atomic oxygen is limited to the surface atoms with no penetration into the bulk of a material. Cleaning produces volatile by-products that are safe to the environment and to the conservator and does not leave residues in the artwork. The unreacted O atoms recombine into O^2, or scatter off the surface and the cleaning actions stops when the production of atomic oxygen ceases. Materials in high state of oxidation, used in many paint pigments are typically not

affected. However, as with all tools or techniques it is reasonable to expect that it may not be suited for all types of surfaces or for every situation. The range of applicability is needs to be studied and will be one of the outcomes of the future research.

BIBLIOGRAPHIE

Banks, B.A. de Groh, K., 2002 Techniques for Measuring Low Earth Orbital Atomic Oxygen. Erosion of Polymers, NASA/TM-2002-211479

Banks, B. A., Rutledge, S. K., Paulsen, P. E., and Stueber, T. J., 1989, Simulation of Low Earth Orbital Atomic Oxygen Interaction with Materials by Means of an Oxygen Ion Beam, 18th Annual Symposium on Applied Vacuum Science and Technology, February 6-8, 1989.

Banks, B. A., Rutledge, S. K., Karla, M., Norris, M., Real, W., Haytas, C., 1999, Use of an Atmospheric Atomic Oxygen Beam for Restoration of Defaced Paintings, proceedings of the 12th Triennial ICOM Meeting, Lyon, France, August 29 - September 4, 1999.

Banks, B. A., Miller, S., Waters, D., 2005 Atomic Oxygen Treatment and Its Effect on a Variety of Artist's Media NASA/TM—2005-213434

Banks, B., Rutledge, S., Chichernea, V., Haytas, C., 2000 Cleaning of Fire Damaged Watercolor and Textiles Using Atomic Oxygen, Studies in Conservation 45 (Supplement-1) p.p. 166-169

Banks, B. A., Miller, S., Tollis, G. 2001, Treatment and Analysis of a Paint Chip From "Water Lilies" a Fire Damaged Monet" NASA/TM—2001-211326

Banks, B.A., Rutledge, S.K., Norris, M.J., 1998, An Atmospheric Atomic Oxygen Source for Cleaning Smoke Damaged Art Objects, NASA/TM—1998-208506

(Baril, P., 1998, Museum Fires and Losses - Canadian Conservation Institute (CCI) Notes 2/7, 1998, Cat. Nº NM95-57/2-7-1998E, ISSN 0714-6221

Ormsby, B., Barker, R., Keefe, M., Tucker, C., Donate, F., Smithen. P., The Removal of Graffiti Ink from Mark Rothko's Untitled (Black on Maroon), 1958. A Collaborative Approach', in Bridgland, J., (ed.), ICOM-CC17thTriennial Conference Preprints, Melbourne, 15–19 September 2014, International Council of Museums, Paris 2014, art.1007, 9pp.

Spacecraft Polymers Atomic Oxygen Durability Handbook, 2014, NASA 20546-0001

Srinivasan, V., Banks, Bruce A., 1990 Materials Degradation in Low Earth Orbit (LEO), Proceedings of the Symposium, 119th Annual Meeting of the Minerals, Metals, and Materials Society, Anaheim, CA, Feb. 17-22, 1990

AUTEURS

TOMAS MARKEVIČIUS

Conservator of paintings, The Munch Museum, 53 Tøyensgata, Oslo, Norway.
tmarkevicius@fulbrightmail.org

SHARON MILLER

Senior Research Engineer, NASA J. Glenn Research Center, 21000 Brookpark Road, Cleveland (OH) USA

BRUCE BANKS

Senior Physicist, Science Applications International Corporation at NASA J. Glenn Research Center

NINA OLSSON

Nina Olsson Art Conservation LLC, 2359 SW Park Place, Portland (OR), USA.