

ARTWORK CLEANING AND RESTORATION SYSTEM USING ATOMIC OXYGEN TREATMENT



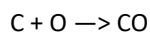
Technical Proposal

TECHNOLOGY OVERVIEW

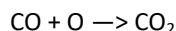
Fires in museums and public buildings can result in complete destruction of artwork on display or can soil the artwork with accumulated soot to an extent to which it can no longer be used for study or be enjoyed by the public. Soot deposits can be very difficult to remove from some types of painted surfaces, particularly those where the paint is fragile or flaking or where damage to the top surface of the paint binder has occurred.

Atomic oxygen (AO) is present in the atmosphere surrounding the Earth at altitudes where satellites typically orbit. It has been shown to react chemically with surface coatings or deposits that contain carbon. The charcoal and soot from fire damage essentially composed of carbon. Through the chemical react atomic oxygen readily oxidizes with surfaces or deposits containing carbon or hydrocarbon molecules. Carbon converts to volatile species via the reactions:

Mostly carbon monoxide



Some carbon dioxide



Possible water vapor may be present if C-H bonds in deposits.

A noncontact technique of removing organic deposits from surfaces and for reviving the appearance of aged paintings and other art objects was developed at NASA Glenn Research Center. This technique was shown to be able to effectively remove smoke damage uniformly on full size paintings. Masking techniques can also be used to treat one area more extensively without leaving visible cleaning lines. Treatment can progress at the discretion of the conservator from light surface cleaning, to more extensive removal of fire damage.

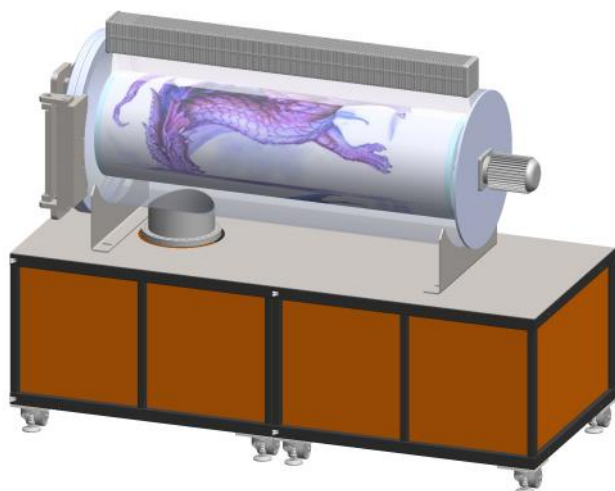


Figure 1. Treatment process in the Artwork Cleaning and Restoration System

TECHNICAL DESIGN AND SPECIFICATIONS

Cleaning of the test articles would be performed in a large vacuum chamber that could hold a painting roughly 2 by 2 m in size. The size was determined partly on availability of a vacuum chamber, and also on the ability to clean a reasonable number of painting sizes. The vacuum in the chamber is provided by conventional vacuum pumps with two large aluminum parallel plates inside the chamber producing the plasma. One plate is connected to an RF power supply operating at roughly 400 W. The second plate is at ground potential.

The articles are hung so that the ground plate is in contact with the back of the piece, thereby shielding the back side from the atomic oxygen during cleaning. A controlled entry of air into the chamber at rates between 50 and 280 standard cm^3/min provides the source of the plasma. Radio frequency oscillation of electrons between the two plates produces splitting of the oxygen in the air into atomic oxygen. The dissociation of the air into atomic species creates a pink colored glow between the plates. The nitrogen in the air has been

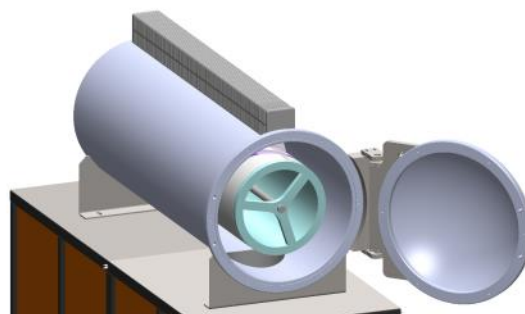


Figure 2. Drum holding a painting inside the chamber

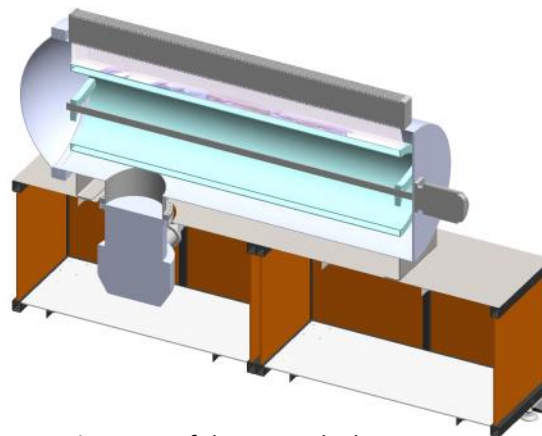


Figure 3. Section view of the Artwork Cleaning and Restoration System

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found not to have an effect on carbon removal and acts as an inert gas for these treatment exposures. An automated timer and controller on the system allows the cleaning to proceed over a desired timeframe unattended and will turn the system off if a loss in vacuum, water cooling to the pumps and power supply or drop in plasma intensity is detected. Figs. 2 and 3 show a preliminary design of the RF AO plasma source, a vacuum chamber, and an associated vacuum pump.

Other supporting equipment of the Artwork Cleaning and Restoration System are a vacuum system, a water-cooling system, electrical and electronics equipment, and a control console. The electrical and electronics equipment is used to control the vacuum system, the AO plasma source, to conduct treatment, and to provide diagnostics.

It is expected that the final design of Artwork Cleaning and Restoration System will have the following technical specifications in Table 1.

CONCLUSION

- Process is in gas phase → no mechanical contact
- Reaction confined to surface → reduced risk of damaging underlying paint or canvas
- Materials already in a high oxidation state (i.e. metal oxides used in many paints) typically unaffected by atomic oxygen
- It is a dry process → no risk of leaching or swelling of painting
- Oxygen molecules dissociated via radio frequency, microwave radiation, or electron bombardment
- Done under partial vacuum → at 0.027-20 Pa (2×10^{-4} to 0.15 Torr), dependent on the oxygen dissociation process used
- Atoms at low energy either directed toward surface or allowed to surround object in closed chamber
- One possible drawback: if paint binder is charred, treatment loosens some of the pigments → need to apply acrylic varnish post-treatment
- Atomic oxygen treatment not intended to replace conventional techniques, but used as an additional conservation tool when traditional methods prove ineffective

Table 1. Technical parameters of the Artwork Cleaning and Restoration System

	Parameter	Value
Vacuum Chamber	Chamber diameter, m	2
	Chamber length, m	2.5
	Volume, m ³	~7.9
	Weight (kg)	TBD***
AO Plasma Source	Excitation type	Radio Frequency
	RF frequency, MHz	13.56
	RF power supply, W	400-1000, adjustable
	AO energy, eV	~0.01
	AO beam flux, atoms/cm ² /s	TBD
Artwork Treatment Unit	Drum's perimeter of circle, m	2
	Max size of painting, m	2×2
Vacuum Pumping System	Pumping rate for Ar (one pump), L/s	2,050
	Vacuum conditions* (base), Torr	5×10^{-7} or better
	Time to reach the base vacuum**, min	40 or less
Gas Flow Instrumentation	Pressure regulator, psi	0-300
	OMEGA FMA-2600A Series Mass and Volumetric Flow Controller	
Control Electronics	Main System Controller	PLC-based
	Type of Data Acquisition Board	National Instruments
	DAQ Sampling Rate (kS/s)	250
Utilities	Supply voltage, V	220-380, 3 Phase
	Supply frequency, Hz	50
	Supply current, A	TBD

* - Notes: All parameters marked with an asterisk in Table 1 will be specified more accurately during the actual design and are given for reference only

** - Applied to a clean vacuum chamber, after high temperature bakeout

*** - To Be Determined