

# Atomic Oxygen Cleaning of Unpainted Plaster Sculptures

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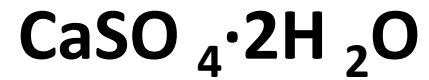
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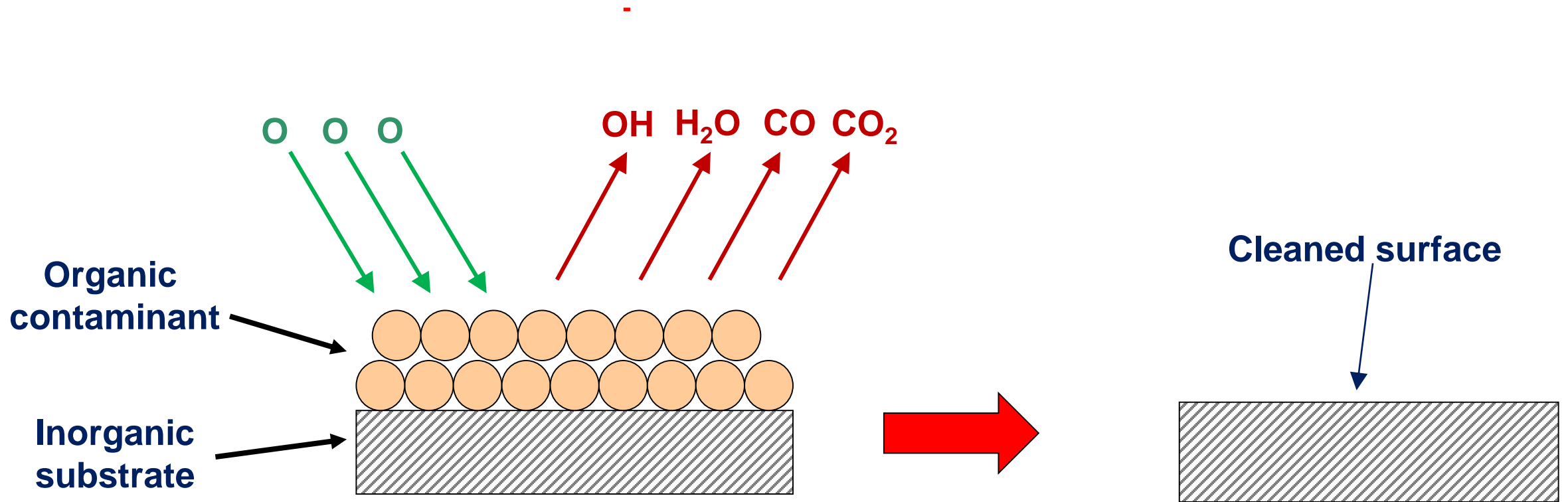
**"Expert Meeting" on the Cleaning of Unpainted Plaster Sculptures  
May 8<sup>th</sup> -9<sup>th</sup>, 2017 at the Ny Carlsberg Glyptotek, Copenhagen, Denmark**

# Gypsum/Plaster of Paris Composition

Gypsum/Plaster of Paris is a crystalline mineral of hydrated calcium sulphate

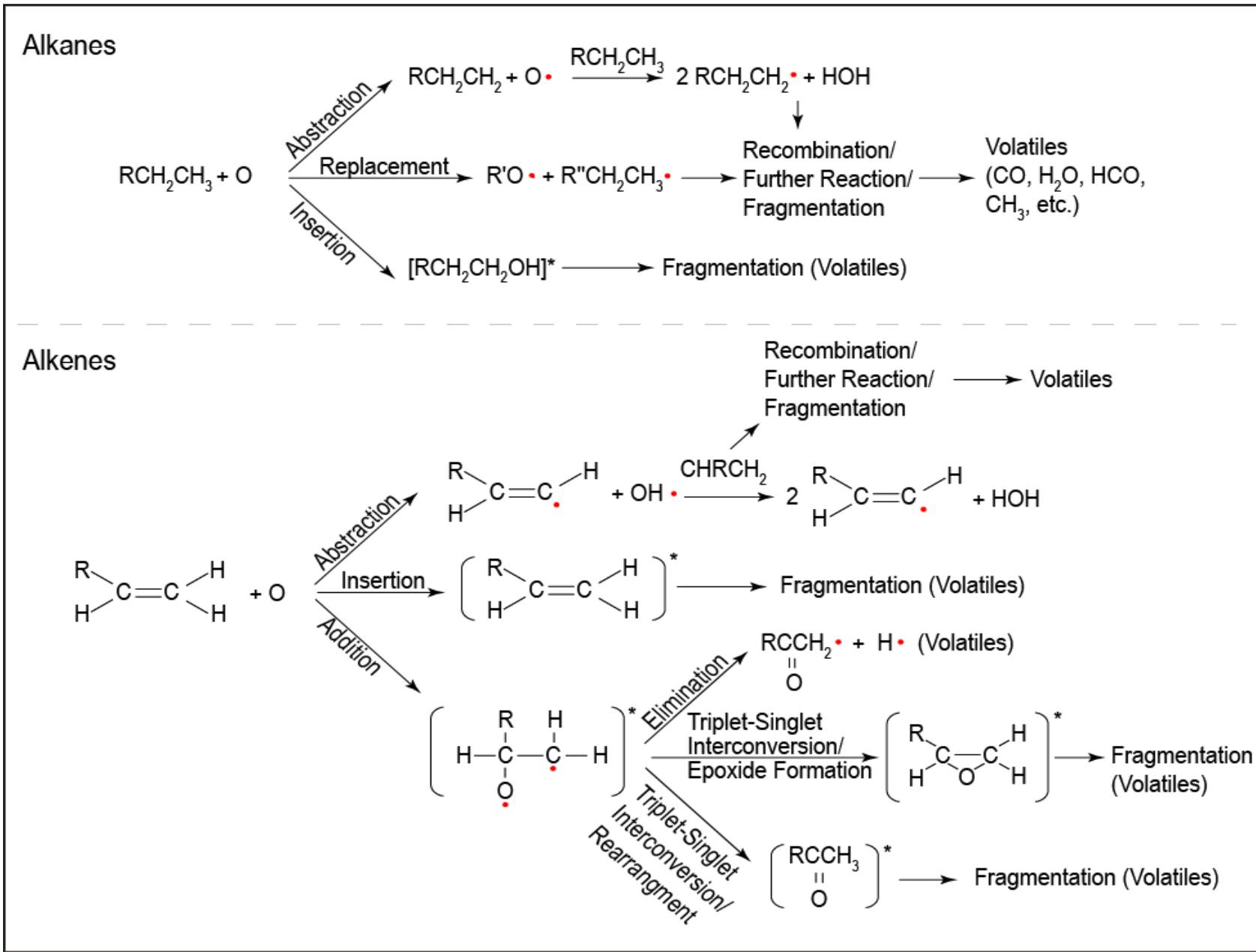


# Atomic Oxygen Removal of Organic Surface Contaminants



# Atomic Oxygen Interactions with Hydrocarbons

All atomic oxygen reactions result in release of volatile oxidation products

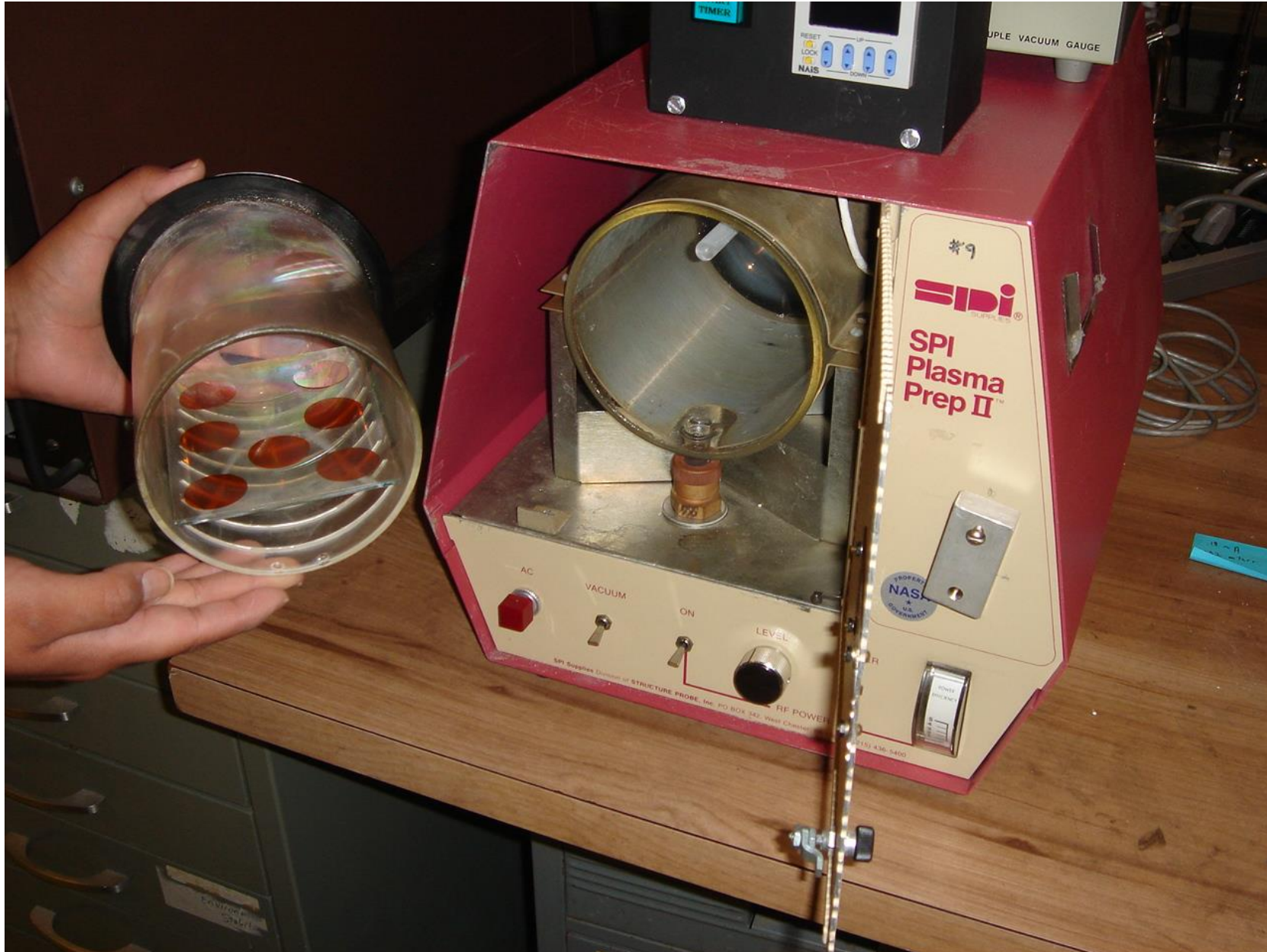


# Radio Frequency Plasma Ashers

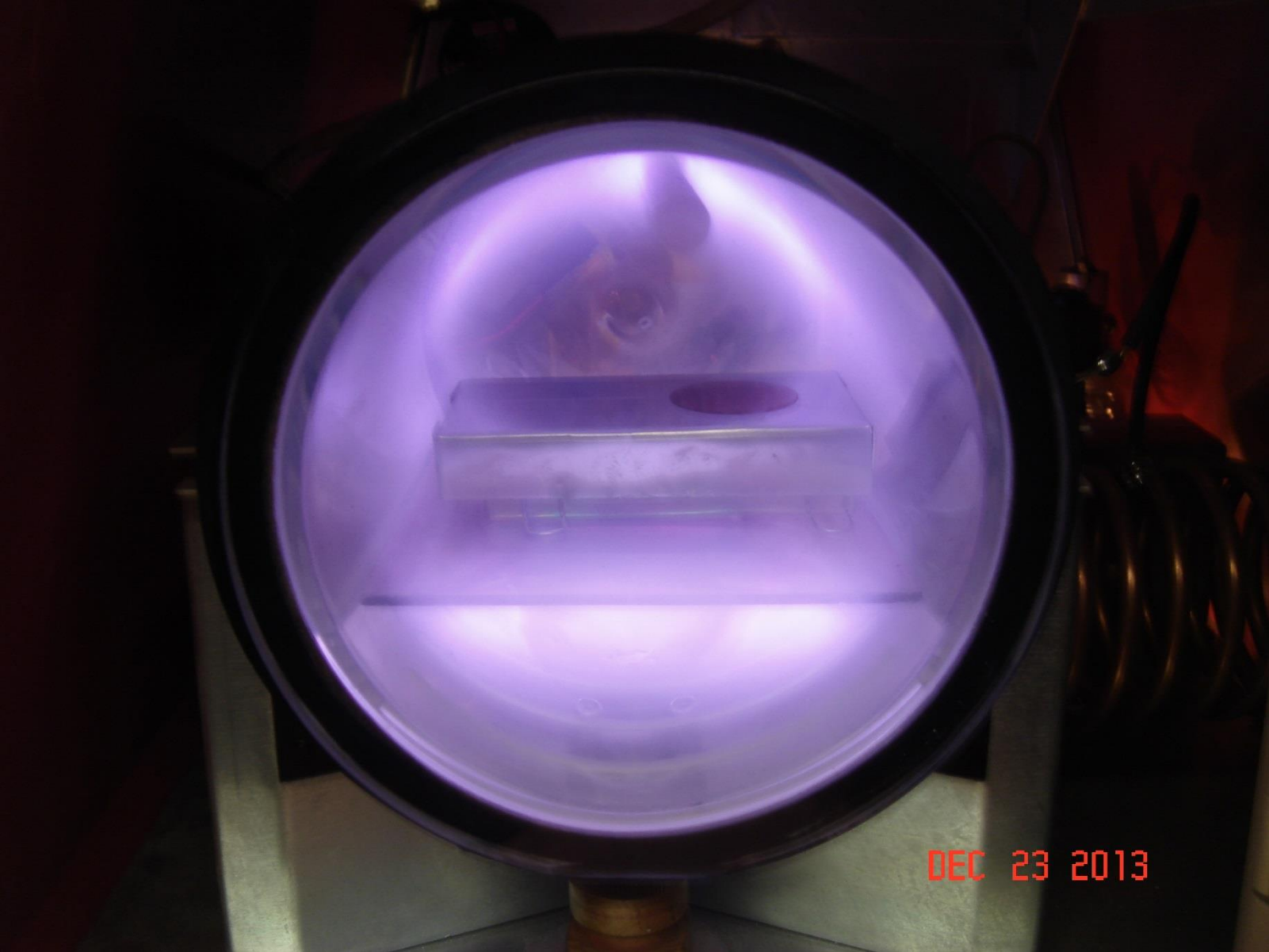




# Radio Frequency Plasma Ashers

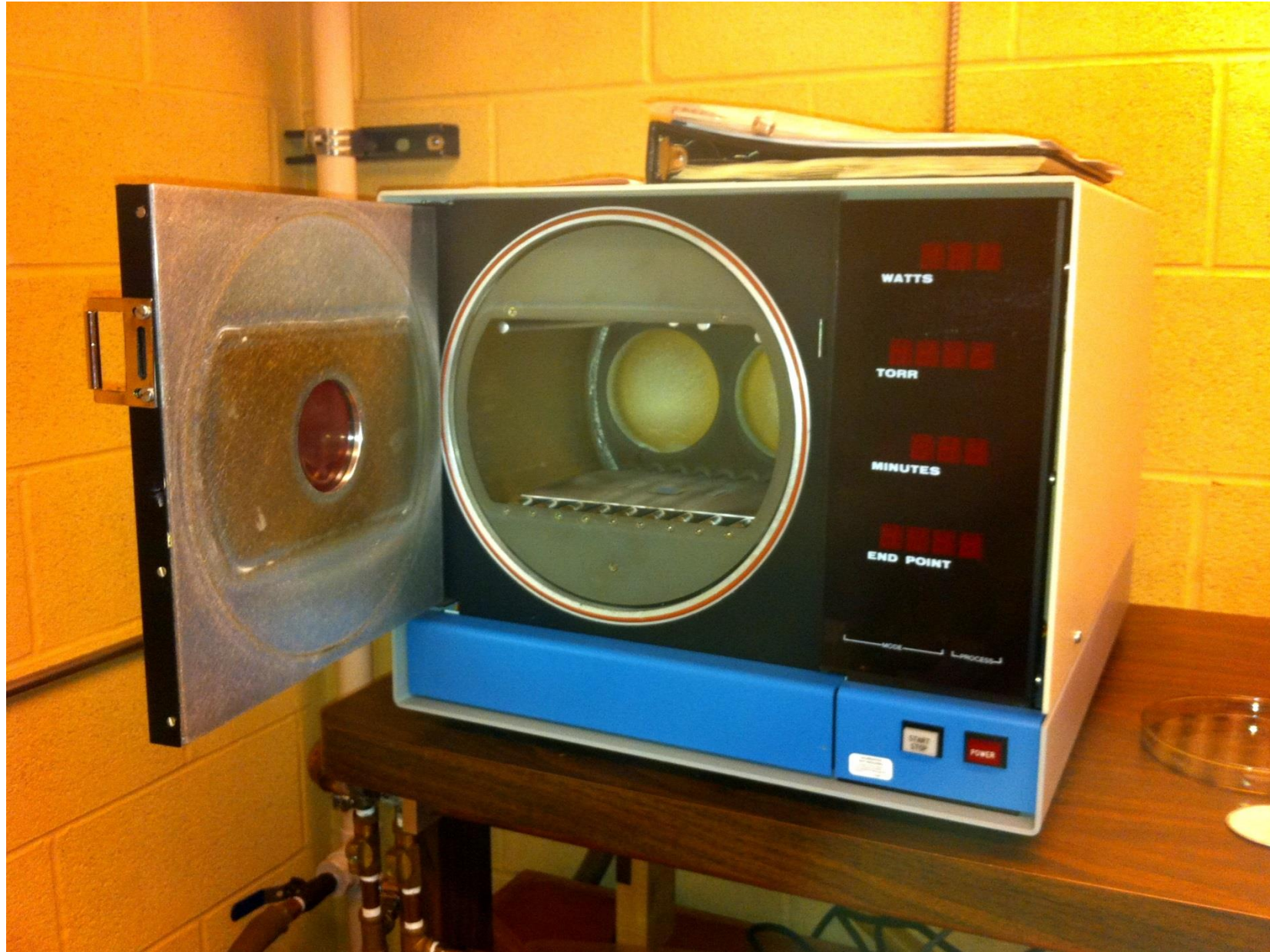


# Radio Frequency Plasma Ashers





# Radio Frequency Plasma Asher

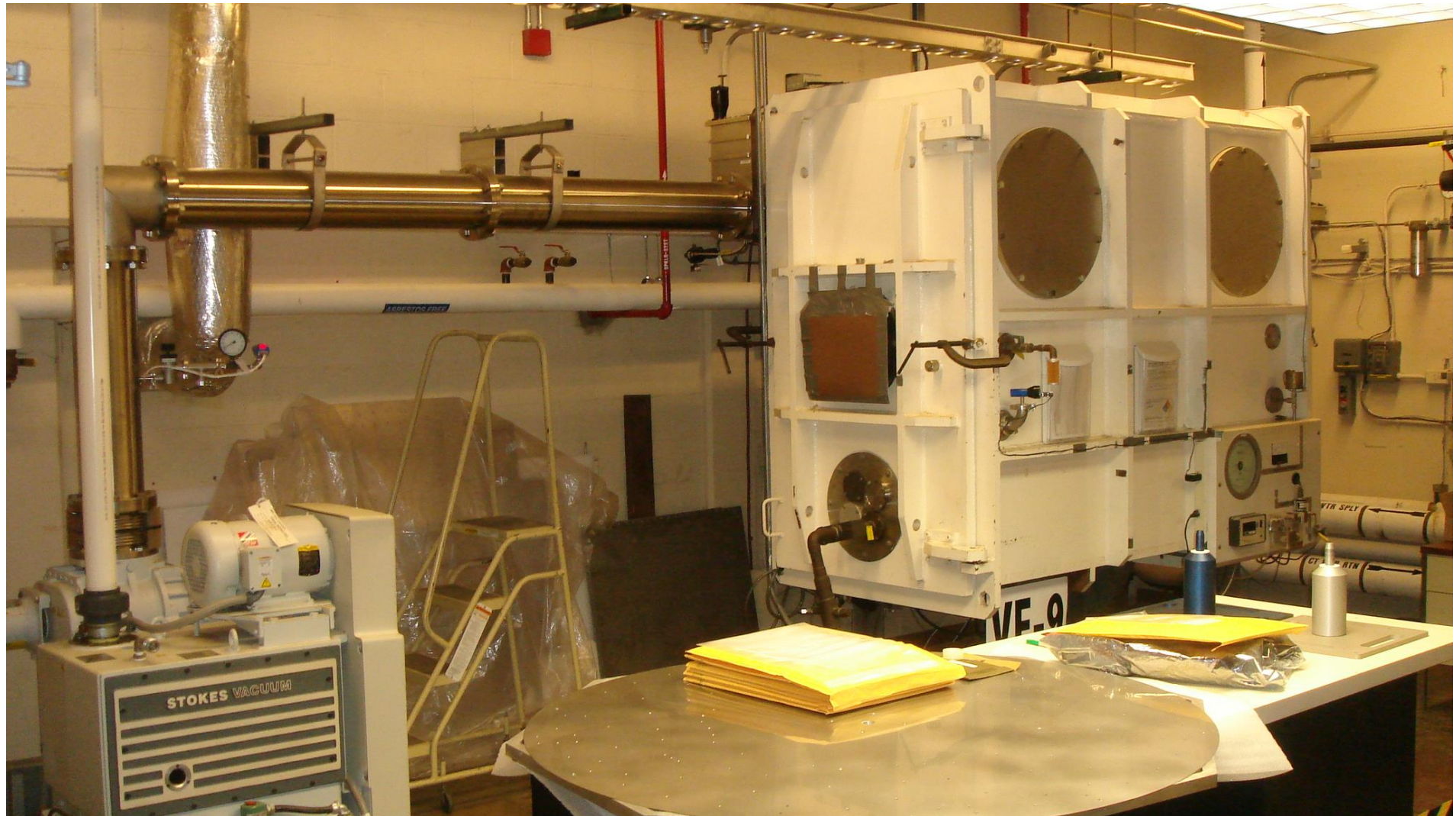




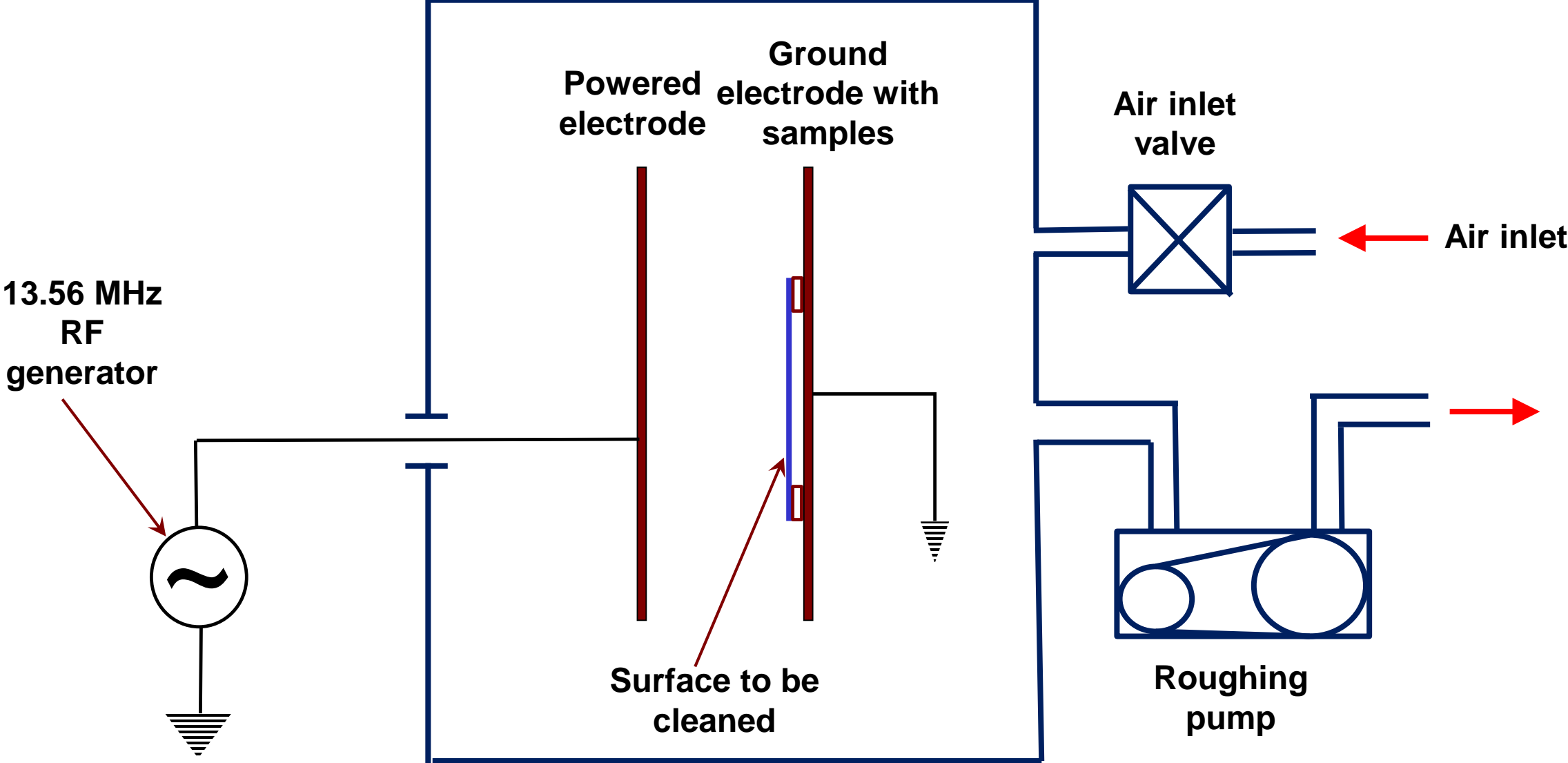
## Large Area Atomic Oxygen Exposure Facility



# Large Area Atomic Oxygen Exposure Facility

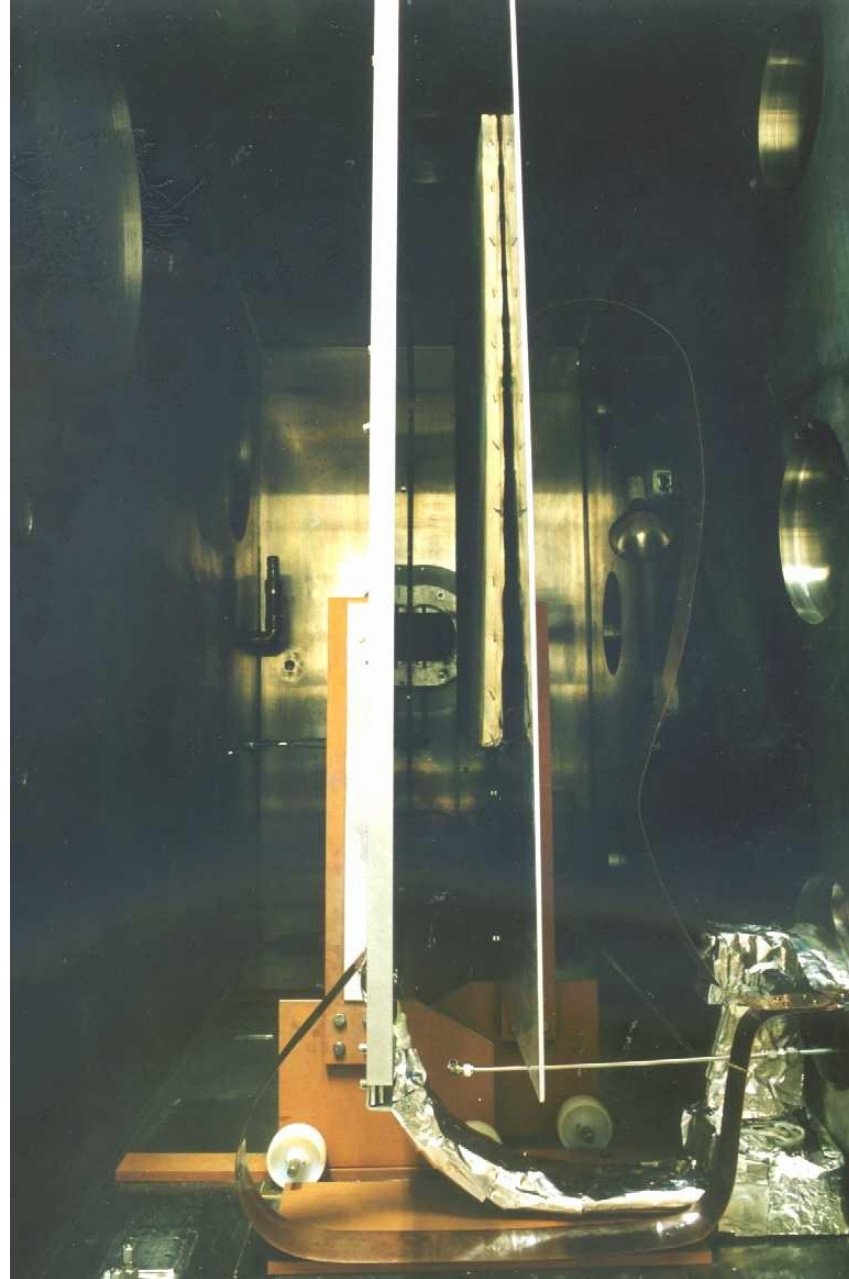


# Schematic of Large Area Atomic Oxygen Exposure Facility

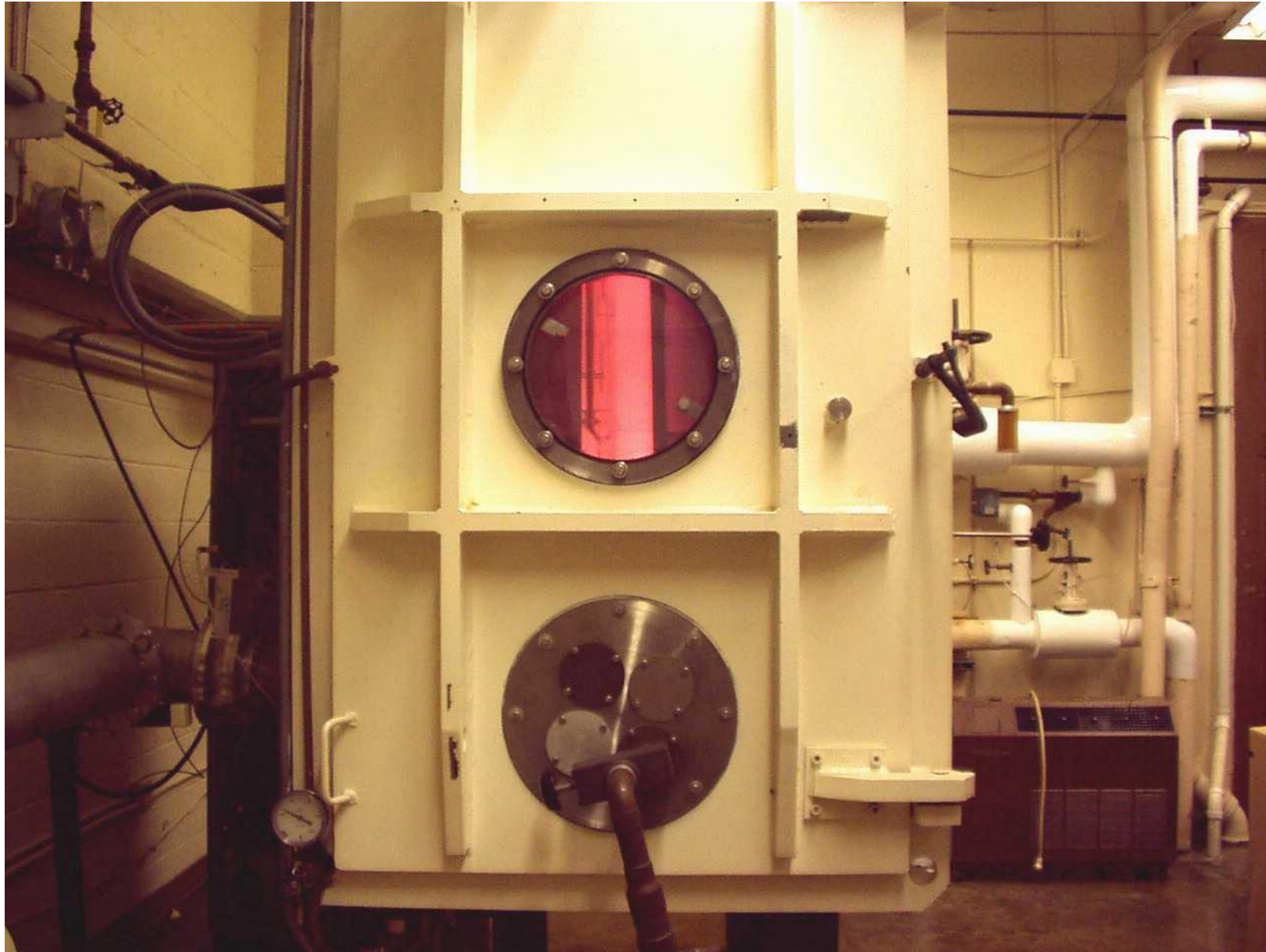




# Exposure Configuration in Large Area Atomic Oxygen Exposure Facility



# Radio Frequency Plasma in Large Area Atomic Oxygen Exposure Facility





## Atomic Oxygen Art Restoration of Smoke Damaged Paintings



**Before atomic oxygen cleaning**



**After atomic oxygen cleaning**



# Atomic Oxygen Art Restoration of Fire Damaged Paintings



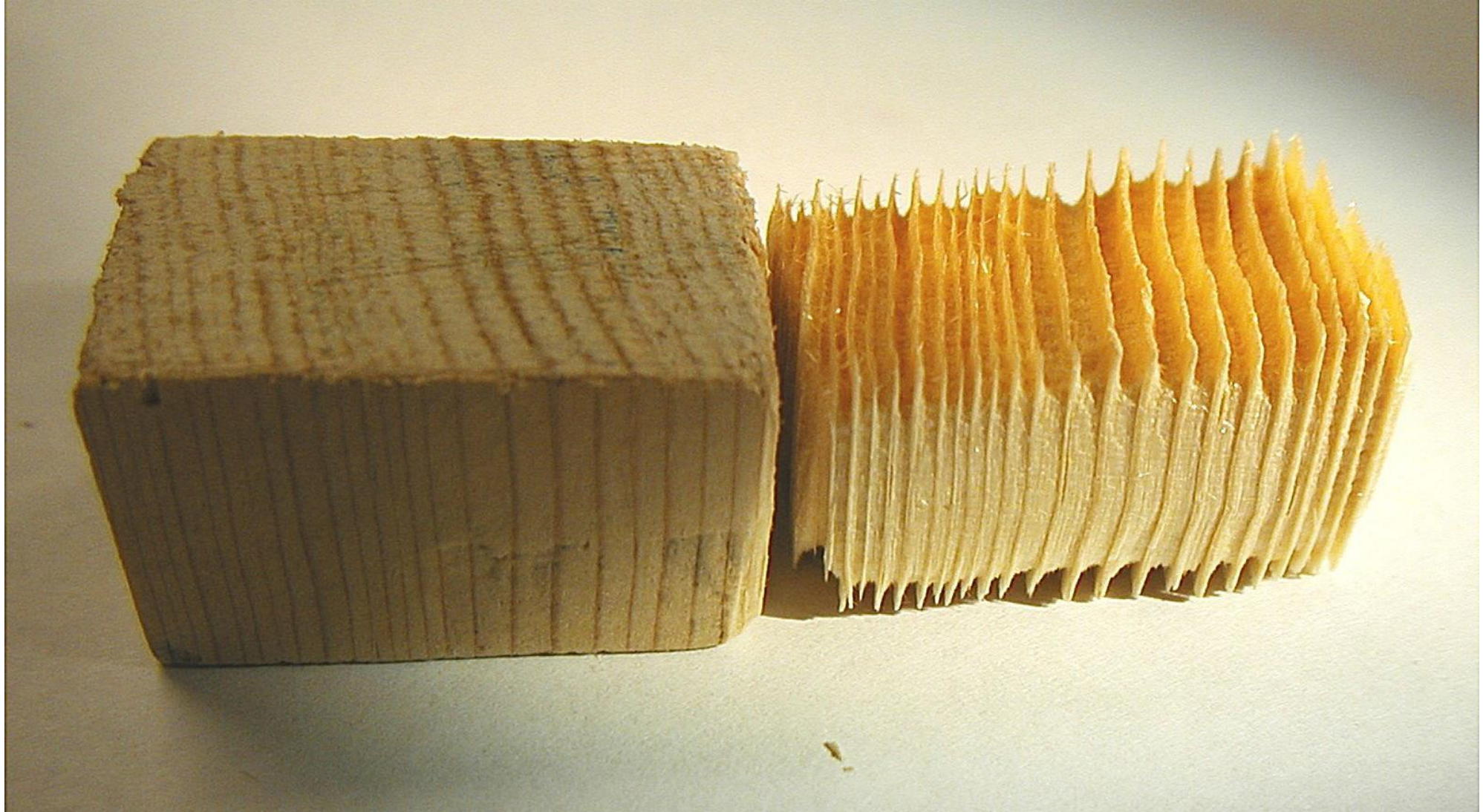
**Fire damaged**



**After atomic oxygen restoration**



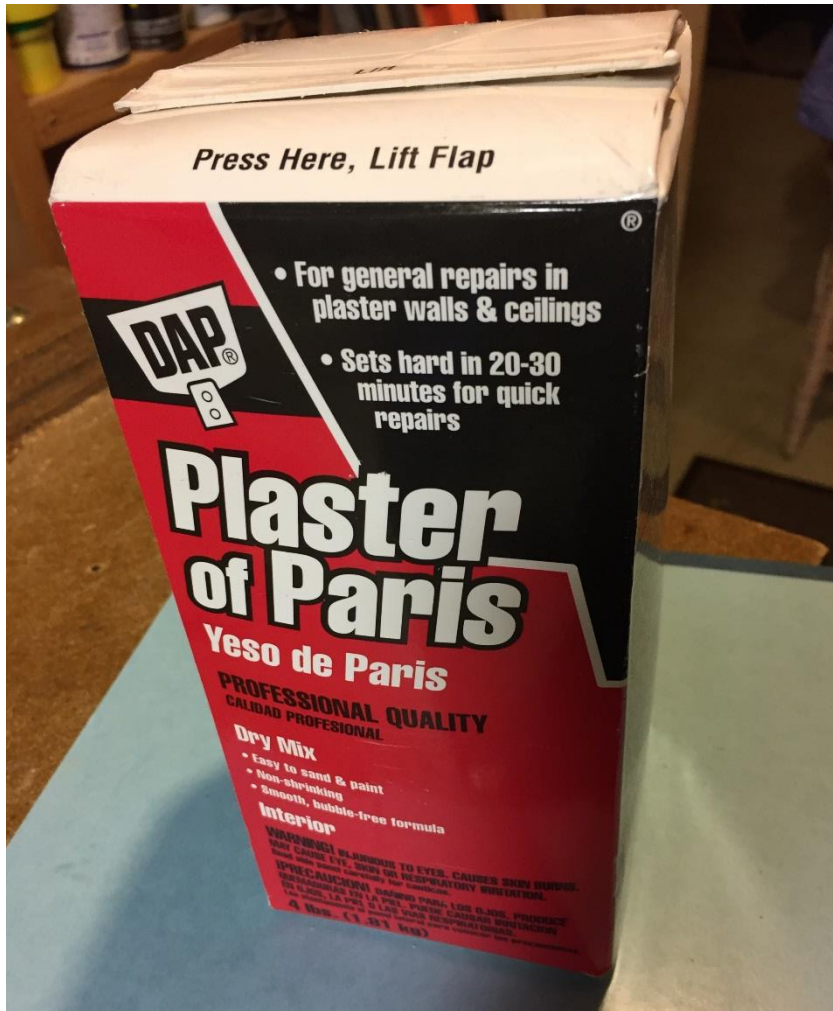
# Pine



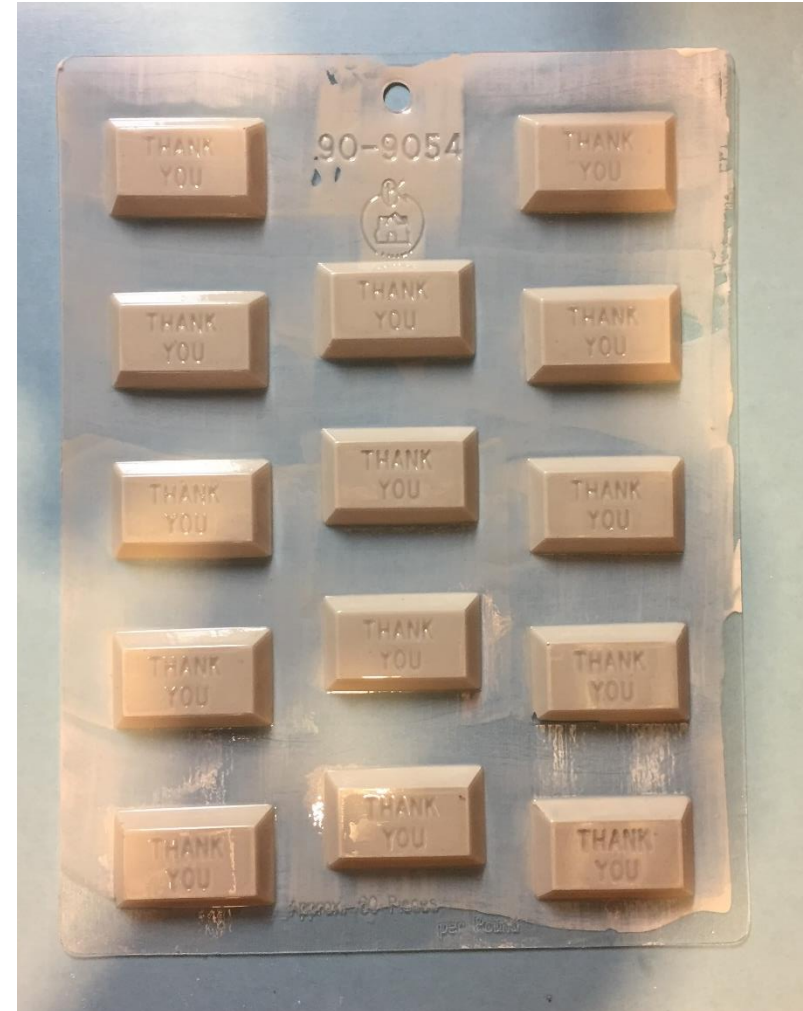
**Untreated**

**Atomic oxygen etched**

# Plaster Sample Preparation



Plaster used



Plaster in molds



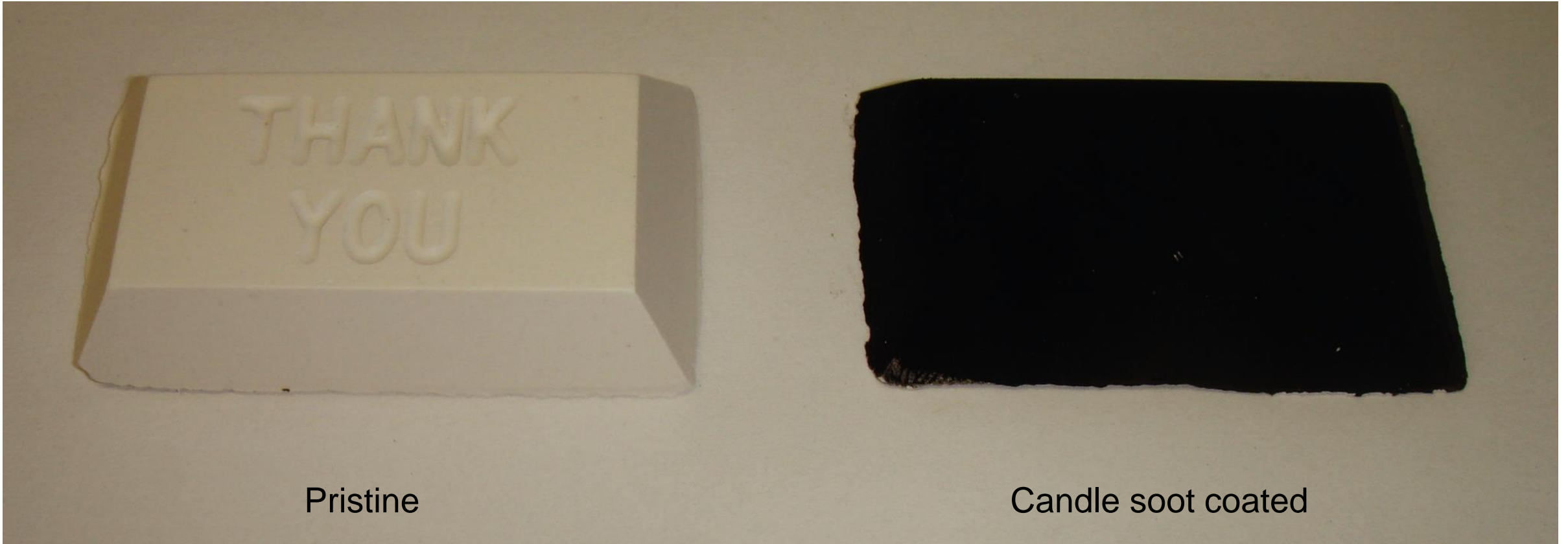
## Plaster Sample



# Plaster Sample Preparation



# Plaster Sample Preparation



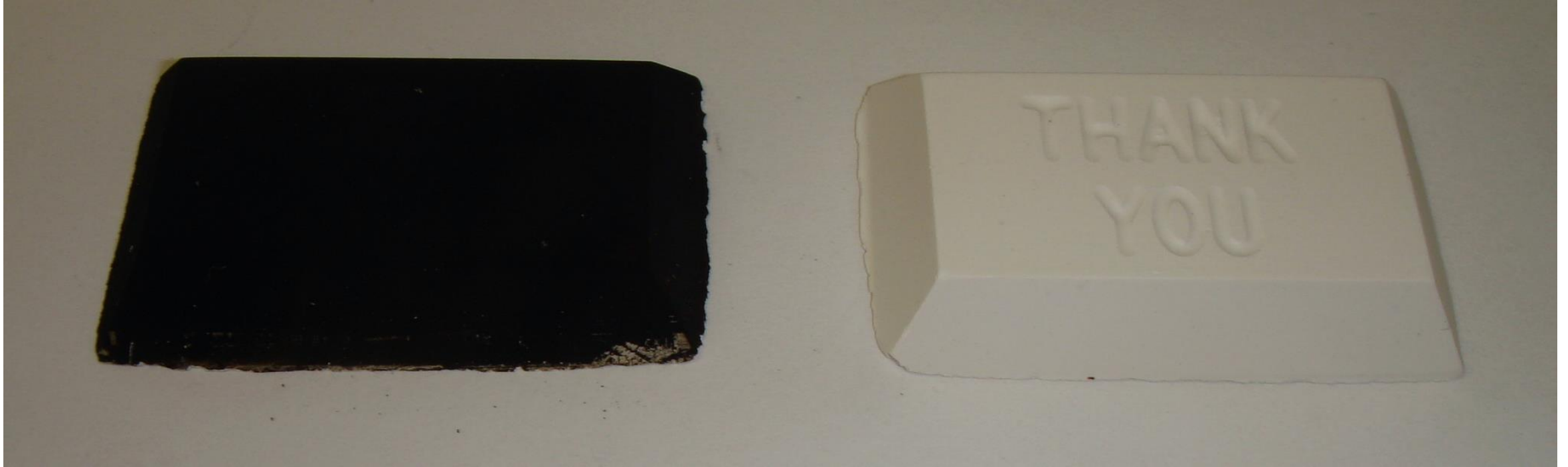
Pristine

Candle soot coated



# Plaster Sample Cleaning Results

Candle soot coated

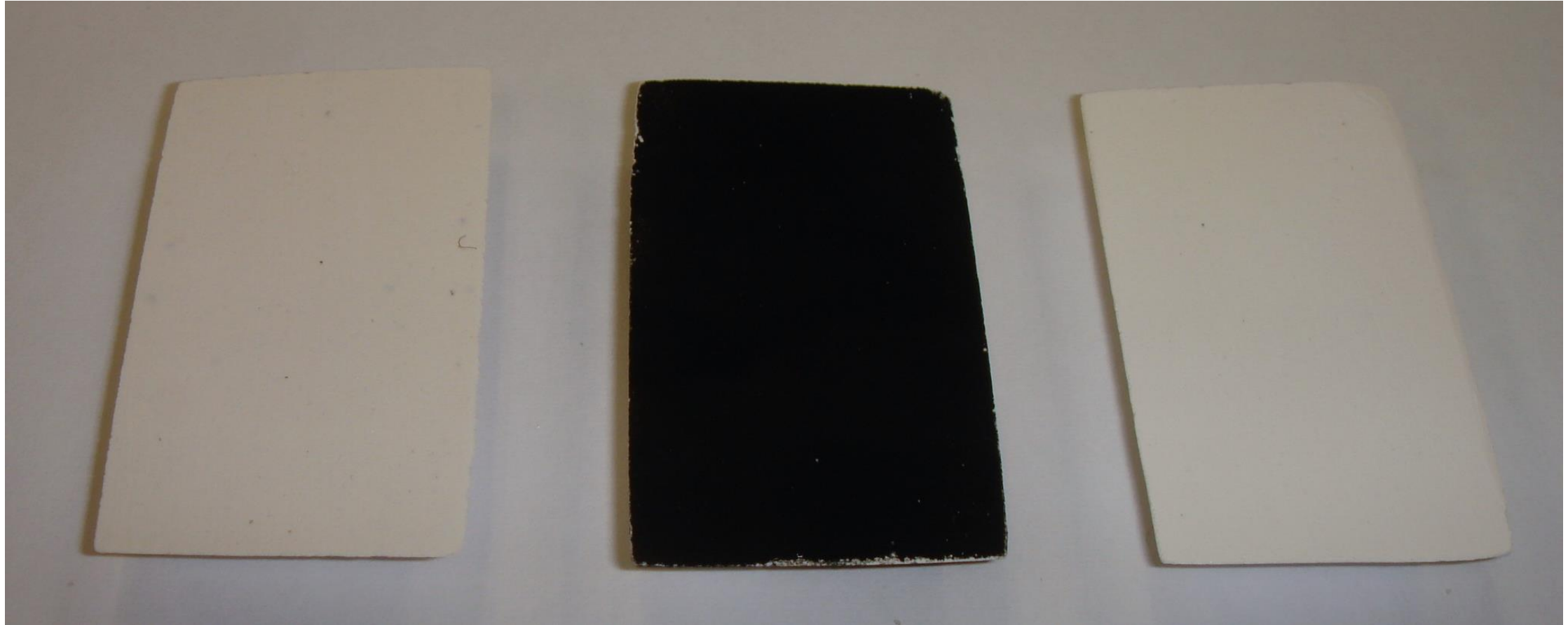


Before atomic oxygen cleaning

After atomic oxygen cleaning for  
15.8 hours

## Plaster Sample Cleaning Results

Candle soot coated on sanded back surface of samples

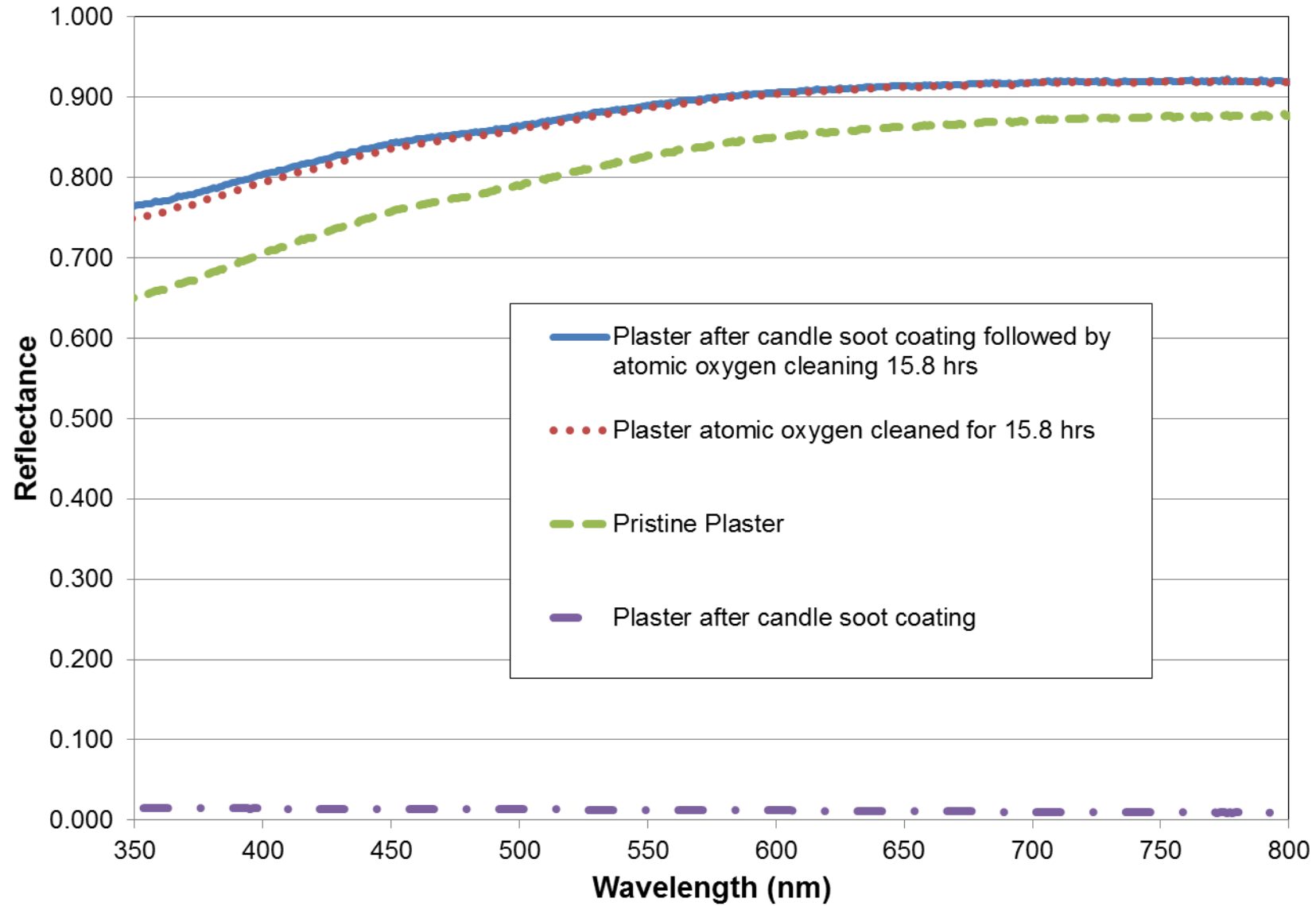


Pristine

Soot coated

After atomic oxygen cleaning  
For 15.8 hours

## Comparison of the Reflectance of Plaster Samples from Cleaning Test (3-17)





## Plaster Sample Preparation



Rubbed with contaminants from automobile exhaust pipe



Rubbed with contaminants from automobile engine oil on engine block

## Plaster Sample Preparation



Rubbed with contaminants from  
automobile exhaust pipe



Rubbed with contaminants from  
automobile engine oil on engine block



## Plaster Sample Atomic Oxygen Cleaning Results



Before



After



Rubbed with contaminants from  
automobile exhaust pipe

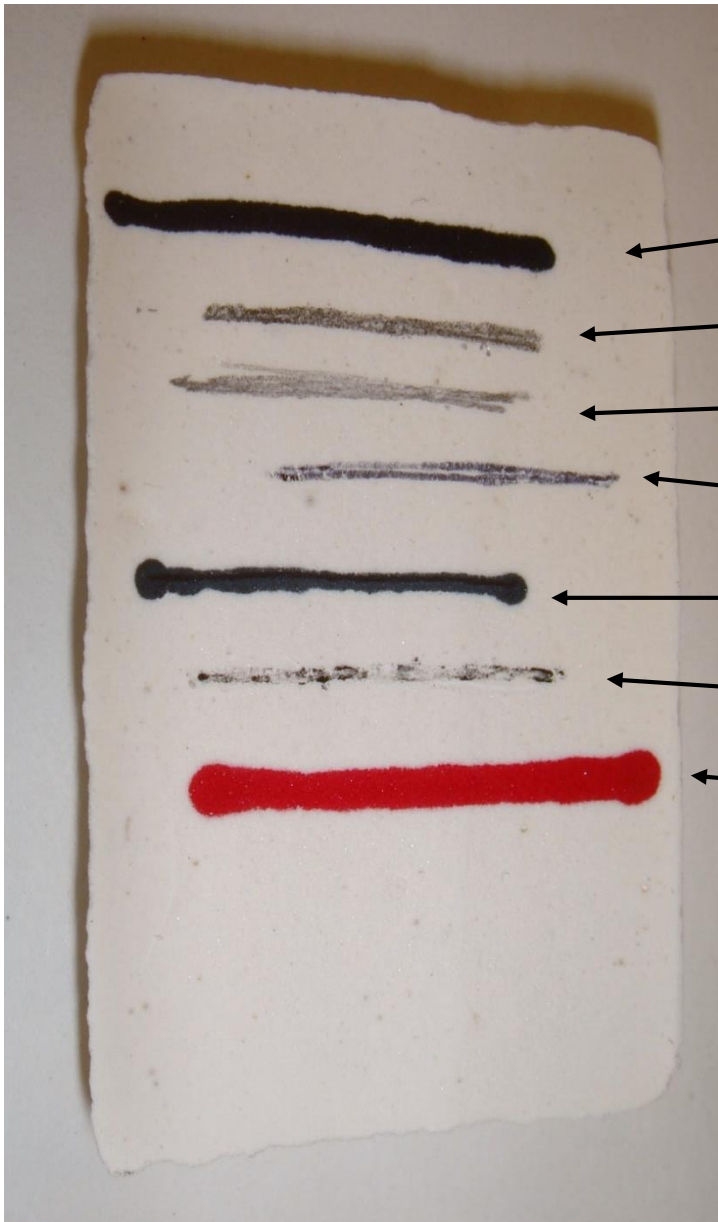
Rubbed with contaminants from  
automobile engine oil on engine block



# Pencil and Pen Markings on Sanded Smooth Samples

Marked samples

After atomic oxygen cleaning



- Black Sharpie
- B1 Pencil
- #2 Pencil
- Paper mate ball point pen
- Paper mate ultrafine flair pen
- Pilot precision gel pen
- Red Sharpie



## Summary

- Atomic oxygen appears ideally suited to remove hydrocarbon contamination from the surface of plaster sculptures.
- If the hydrocarbon contamination has inorganic content, atomic oxygen cleaning may leave some traces of inorganic residue on the surface.
- There is no abrasion to the plaster sculptures during cleaning with atomic oxygen.
- The highly reactive atomic oxygen is able to get around corners and into crevices
- The reaction products with pure hydrocarbons are simple dilute gases leaving no contamination on the surfaces of the plaster sculptures.
- The cleaning process can be stopped at any point so that a surface can be partially or fully cleaned in order to obtain the desired color on the surface.