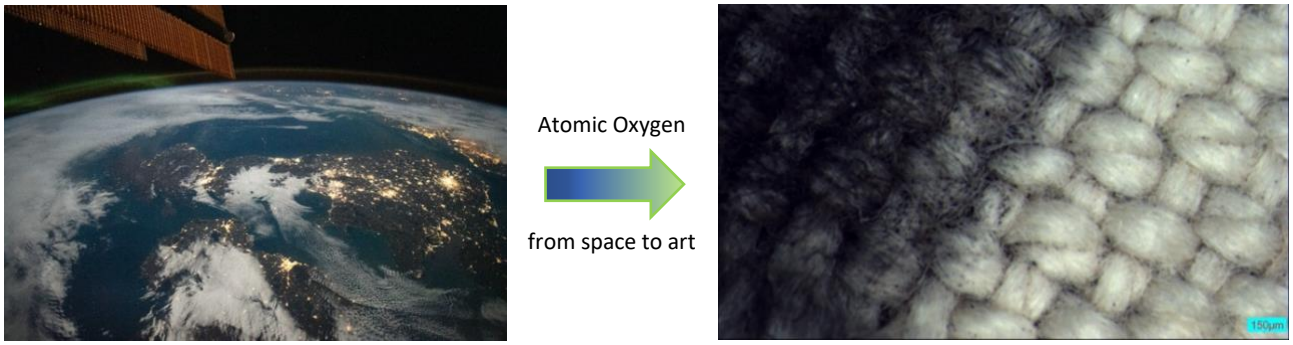
European Commission awards Horizon Europe research grant to MOXY project: Green Atmospheric Plasma Generated Monoatomic OXYgen Technology for Restoration of the Works of Art

Works of art and tangible cultural heritage assets constitute an invaluable and irreplaceable resource of humanity, which is increasingly threatened by contaminants from pollution, vandalism, smoke, fire, and many other factors. Currently available cleaning methods require contact with the surface, mechanical action, liquids, countless chemicals, and auxiliary means, which increase the carbon footprint of treatments. Their efficiency can be limited, and they can be detrimental to art materials, as well as harmful to health and the environment, and unsustainable in the long term. The urgent need for sustainable green approaches has been emphasized for over a decade, summarized in ICOM-CC's Melbourne 2014 declaration, but the actual progress in creating green solutions has been very slow.

To kick-start a breakthrough, the European Commission has funded *Green Atmospheric Plasma Generated **M**onoatomic **OXY**gen Technology for Restoration of the Works of Art – MOXY* project 2022-2026, coordinated by Ghent University with a Horizon Europe grant in the call *Green Technologies and Materials for Cultural Heritage: HORIZON-CL2-2021-HERITAGE-01-01* (grant agreement ID: 101061336) to bring to fruition a radically new approach to the cleaning of tangible cultural heritage assets, based on atomic oxygen, which will empower practitioners in diverse areas of conservation to safely remove highly problematic contaminants in a contact-free, non-mechanical, solvent-free and liquid-free action, without health or environmental concerns, or waste.



A green band of oxygen glow is visible over Earth's curve. In natural conditions, atomic oxygen extends from about 80 km to above 300 km, with over 90% concentrated between 85 - 125 km. MOXY aims to bring this space environment material for green transformation to cultural heritage conservation. At the European Space Agency MOXY researchers experimented with a space environment simulator to remove soot from unprimed cotton canvas and other typical art materials in a non-contact way using oxygen atoms, as seen under the microscope (right). Images: NASA (ID: iss066e118171) and Ghent University.

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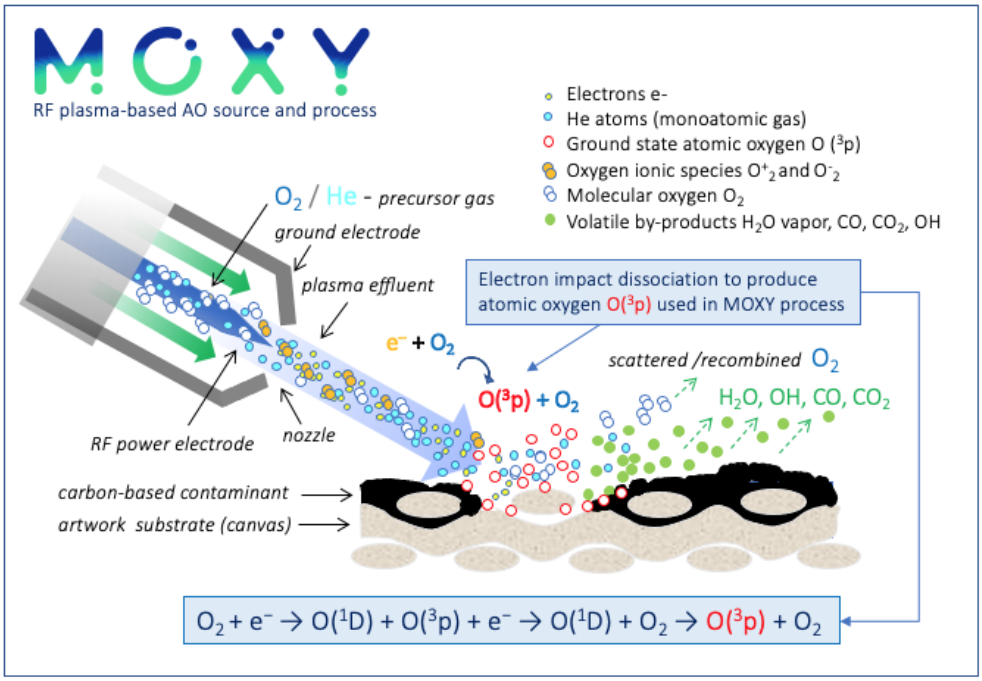
MOXY aims to lead the green transformation in cultural heritage conservation by developing a clean technology, which uses nothing but oxygen atoms to remove diverse carbon-based contaminants from sensitive cultural heritage materials in a non-contact way. The project is ambitious, as it literally aims to harness a material from the space environment - atomic oxygen - which exists in natural conditions in the upper layers of Earth's atmosphere, where powerful solar ultraviolet radiation splits O_2 molecules into atoms. The monatomic O does not recombine easily in space into the diatomic form O_2 or ozone, because the oxygen density is much lower and therefore has fewer interactions.

The conditions are very different on the ground, where oxygen atoms nearly instantly recombine to O_2, ozone or quickly react with other unattached or weakly bonded atoms. The MOXY concept aims to couple the extremely short lifetime of oxygen atoms on the ground, with its high chemical reactivity, as a basis for contactless atomic-scale removal of carbon-based contaminants that deteriorate cultural heritage assets – soot, combustion products, hydrocarbons, and organic compounds that ablate literally into "thin air", producing only small amounts of volatile and benign environmental by-products, such as CO, CO_2, or H_2O vapor.

The basis of the innovative MOXY concept stems from the work of two NASA scientists - Sharon Rutledge Miller and Bruce Banks, who first applied atomic oxygen in the 1990s to clean cultural heritage materials and successfully used oxygen atoms to remove lipstick vandalism from a porous white acrylic paint on an Andy Warhol painting, "Bathtub" (1961), at the Andy Warhol Museum in Pittsburgh, PA, the United States. See details: https://users.ugent.be/~anikifor/Atomic_oxygen_artcons.pdf



Since then, atomic oxygen has remained unavailable to cultural heritage scientists or conservators. The MOXY team aims to bridge this knowledge gap and bring the material from the space environment to the cultural heritage conservation field. To enable a breakthrough, experts from plasma physics, green chemistry, heritage science, and conservation from 10 European research organizations, museums, SMEs, and NGOs from 6 European Member states have joined forces in the MOXY project, which officially starts with a kick-off meeting at Ghent University on November 7, 2022 with an opening remarks by atomic oxygen pioneers Bruce Banks and Sharon Miller by virtual bridge, connecting MOXY and NASA teams, as the MOXY mission and the new European research project starts.

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MOXY consortium	Main relevant expertise and role
Ghent University (BE) - Coordinator www.ugent.be/ea/appliedphysics/en/research/plasma	*Public research organization.* Study of atmospheric non-thermal plasmas and their interaction with substrates. Innovation in plasma technologies and engineering. Project coordination, communication, dissemination, exploitation.
University of Amsterdam (NL) www.uva.nl/en/discipline/conservation-and-restoration/conservation-and-restoration	*Public research organization.* Science for cultural heritage science, conservation-restoration, training of conservators-restorers, study of cultural heritage and art materials, development of new conservation technologies and materials, dissemination.
University of Antwerp (BE) www.uantwerpen.be/arches	*Public research organization.* Science for cultural heritage science, conservation-restoration, study of art materials, development of conservation technologies and materials, dissemination, communication, public outreach.
National Gallery of Denmark (DK) www.smk.dk/en/	*National museum.* Conservation-restoration, study of art materials and techniques, innovation in conservation-restoration methods and materials, dissemination.
University of Pisa (IT) https://ricerca.dcci.unipi.it/scibec.html	*Public research organization*. Chemical science for the safeguard of cultural heritage, study of art and conservation-restoration materials, development and implementation of analytical methods based on chromatography and mass spectrometry for the characterization of organic materials, training of chemists and material scientists, dissemination
Eindhoven University of Technology (NL) www.tue.nl/en/research/research-groups/elementary-processes-in-gas-discharges/atmospheric-pressure-non-thermal-plasmas-and-their-interaction-with-substrates/	*Public research organization.* Plasma physics, technologies, and engineering. Study of atmospheric non-thermal plasmas and their interaction with substrates, dissemination, communication, and public outreach.
Kompiuterinis Procesu Valdymas (LT) www.kpv.lt	*University spin-off SME*. Development of precision scientific instrumentation, prototyping atomic oxygen sensing system.
Moderna Museet (SE) www.modernamuseet.se/stockholm/en/	*Public museum.* Conservation-restoration, study of art materials and techniques, innovation in conservation methods and materials, communication, public outreach.
ICOMOS Lietuva (LT) www.icomos-lietuva.org	*ICOMOS National Committee, NGO.* International expert network for safeguarding of cultural heritage. Communication, dissemination, public outreach and engagement, networking.
WeLoop (FR) www.weloop.org	*Start-up, SME.* Consultancy in sustainability, social and environmental impacts via Life Cycle Assessment (LCA), circularity, and raw material criticality.

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