Green technologies and materials for Cultural Heritage Conservation

Piero Baglioni, CSGI and Department of Chemistry, University of Florence, Italy

La cooperazione bilaterale italo-francese nelle scienze per il patrimonio: il patrimonio culturale nella transizione verde
Coopération bilatérale franco-italienne en sciences du patrimoine : le patrimoine culturel dans la transition verte
Consiglio Nazionale delle Ricerche, Piazzale Aldo Moro 7, Roma
giovedì, 15 settembre 2022 / *jeudi, 15 septembre 2022*

Green technologies and materials for Cultural Heritage Conservation

ART: natural aging, degradation

Beato Angelico wall paintings, Florence

Templo Mayor (Mexico City)

Green technologies and materials for Cultural Heritage Conservation

CONSERVATION: a comparison with medicine..

Although the **conservation of cultural heritage** involves a different code of ethics, it can be **compared to medicine**, where **artefacts** are analogous to **patients** and **conservators** are similar to **doctors**.

Diagnosis, treatment and prevention are relevant to the conservation of artefacts: SCIENCE is contributing to such activities.

Green technologies and materials for Cultural Heritage Conservation

Access and transfer to future generation of cultural heritage is possible only if the **original artefacts** are properly conserved, which is **NOT** an **EASY TASK**

An example:

MODERN and CONTEMPORARY ART ONLY

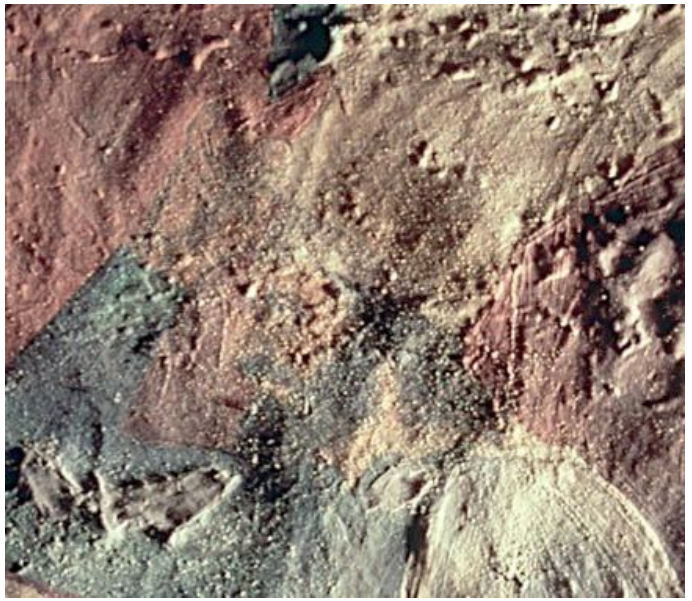
Museums	Modern/contemporary Works of art
MOMA	150,000
Musée d'art moderne de la ville de Paris	10,000
Centre G.Pompidou -Le Beaubourg	100,000
MAV/VAL - Musée d'Art Contemporain du Val-de-Marne	2,000
Tate	ca. 1,000 on display
Museo Nacional Centro de Arte Reina Sofía	10,000
Peggy Guggenheim Collection - Venice	ca. 500
Rijks Museum of Amsterdam	30,000

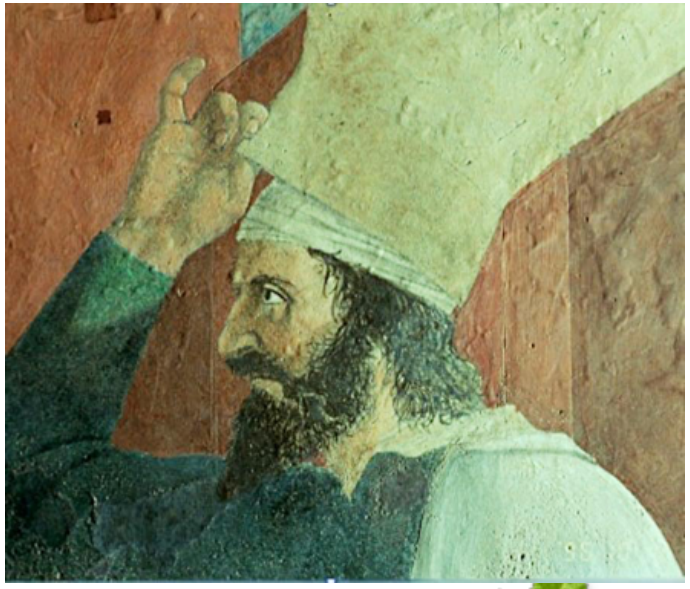
Huge # of artifacts: cannot be conserved with conventional technologies

NEED FOR NEW FAST AND SAFE METHODS

A NEW SCIENTIFIC FRAMEWORK IS NECESSARY

Green technologies and materials for Cultural Heritage Conservation





PIERO DELLA FRANCESCA, AREZZO

BEATO ANGELICO WALL PAINTINGS, FLORENCE

Green technologies and materials for Cultural Heritage Conservation

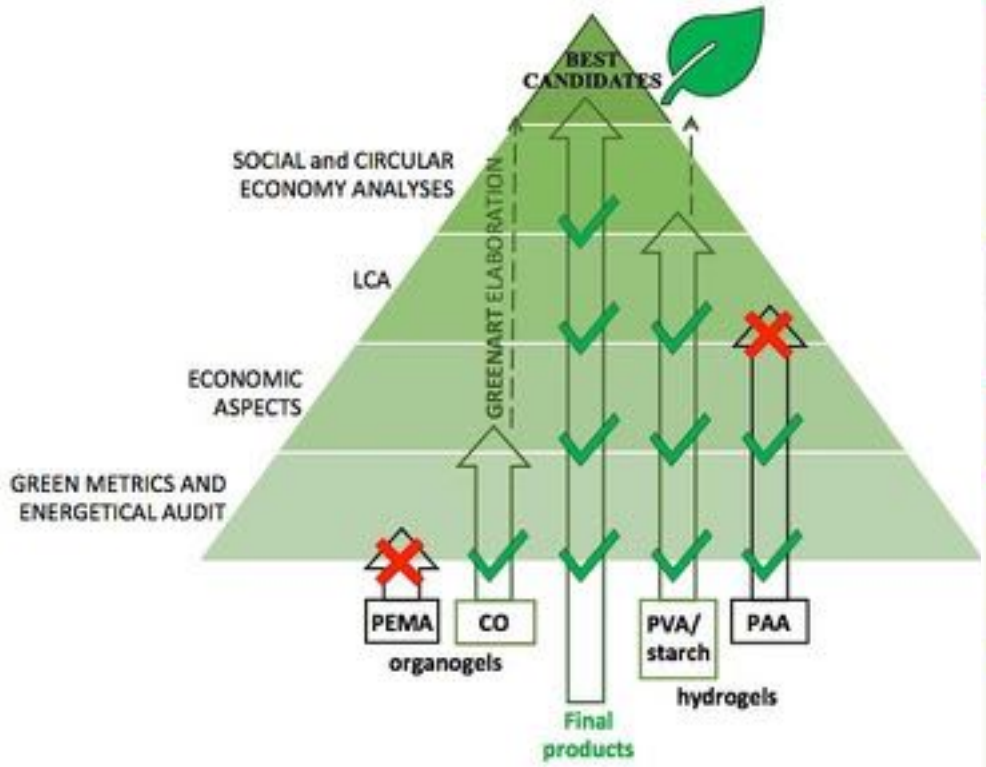
EU INITIATIVES

The European projects in the framework of the 7th and H2020 research programmes

NANORESTART, NANOFORART, INNOVACONCRETE, NANOCATHEDRAL, MEMOSINE, HEROMAT, NANOMATCH APACHE, GREEN ART

generated new **groundbreaking materials and methods** (so far more than 62 new materials, 47 from CSGI) based on **nanoscience** for the conservation of our HERITAGE

Green technologies and materials for Cultural Heritage Conservation



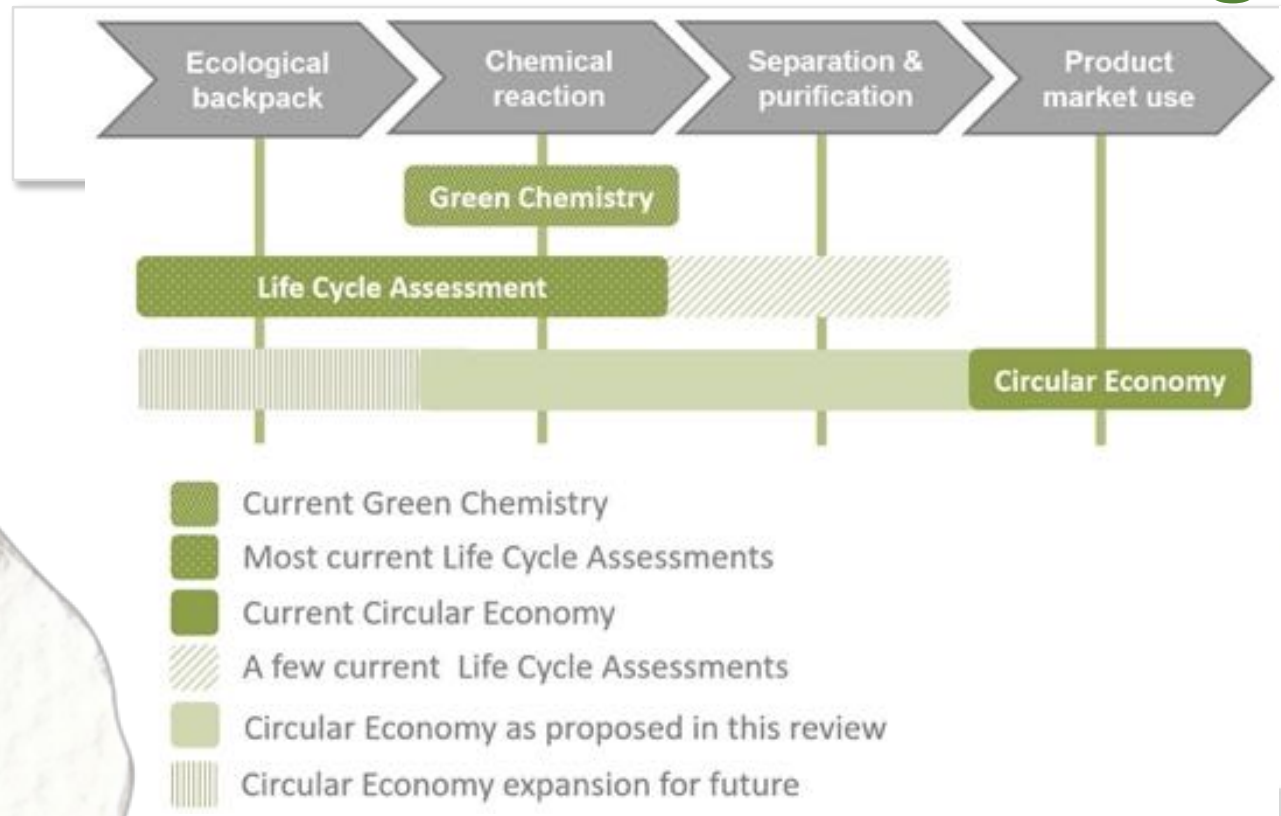
Gels for cleaning works of art - Selection based on LCA		Solvents and reagents	Additional tools (rinsing)
Traditional benchmark	Polyacrylic acid (PAA)-based thickener[b]	Acrylic acid, amines	Petroleum ether and throw away cotton swabs to remove PAA and amines residues
GREENART system	Poly vinyl alcohol (PVA)-based hydrogel elaborated with starch or cellulose	**Polyvinyl alcohol, starch/cellulose, water**	**None**

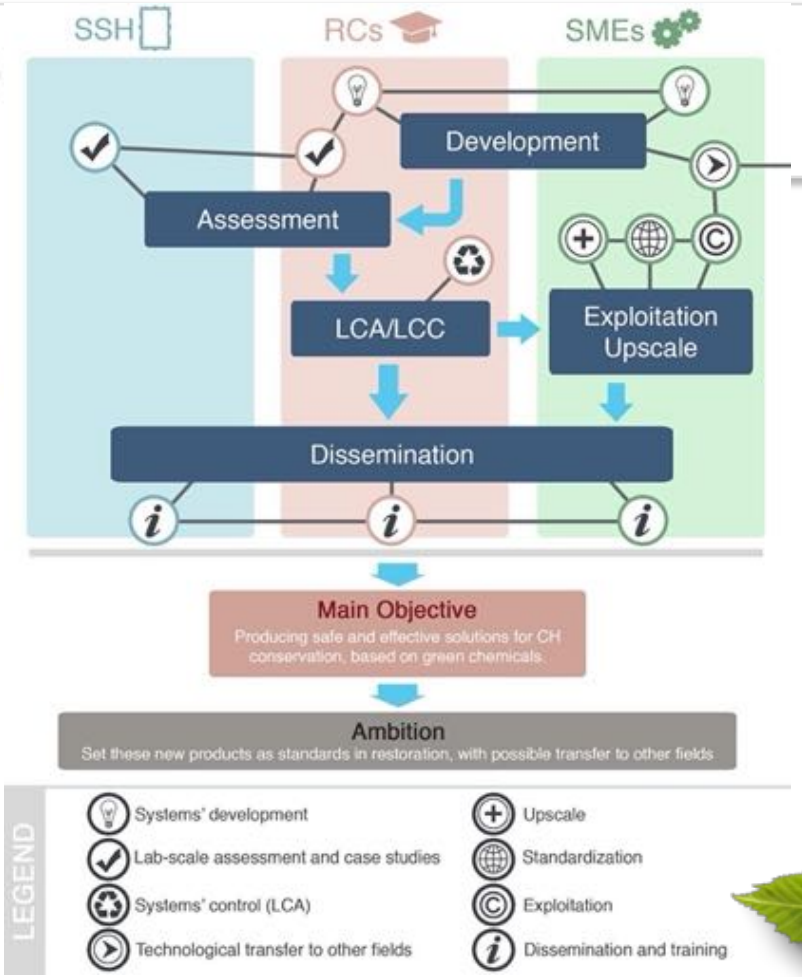
[b] "The conservation of easel paintings", Hill Stoner J and Rushfield R (eds), Routledge, NY (2012), pp. 500-523.

Fluids for cleaning works of art - Selection based on LCA		Solvents and reagents	Additional tools (rinsing)
Traditional benchmark	Blends of solvents	Petroleum-based mineral spirits, xylene/toluene, benzyl alcohol	
State-of-the-art system	Oil-in-water microemulsions[a]	Water (>70%), pentanol, propylene carbonate, ethyl acetate, sodium dodecyl sulphate (< 4%)	Water-loaded hydrogels to safely remove surfactants residues
GREENART system	Oil-in-water microemulsions elaborated with green solvents/surfactants	Water (>70%), alcohols, esters/lactones and alkyl carbonates (**REACH/CHEM21** recommended), biodegradable/bio-surfactants	Water-loaded hydrogels, or none (surfactants are bio- or self-degradable)

[a] Chelazzi D et al (2020) Curr Opin Colloid Interface Sci 45, 108-123.

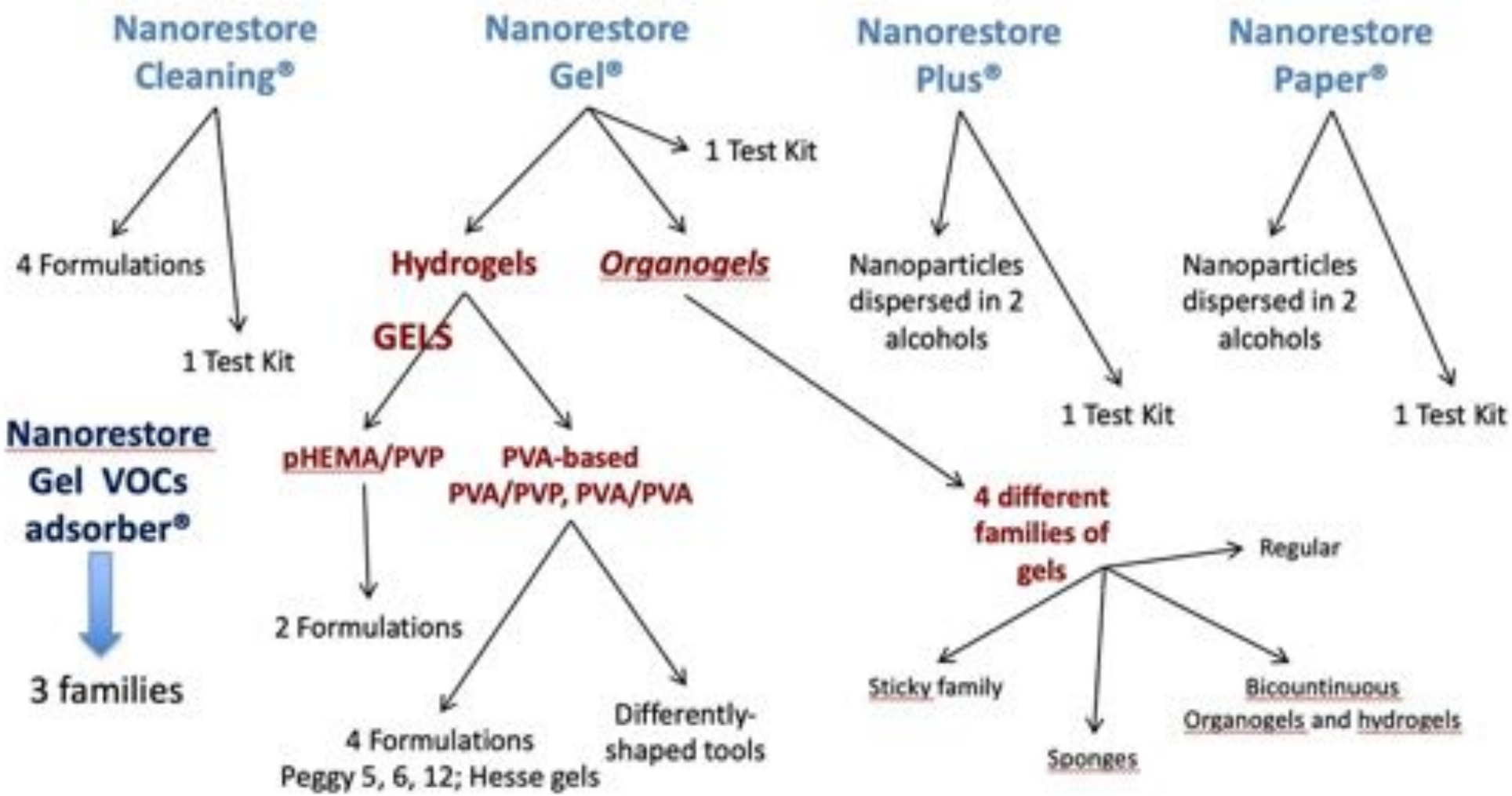
Green technologies and materials for Cultural Heritage Conservation





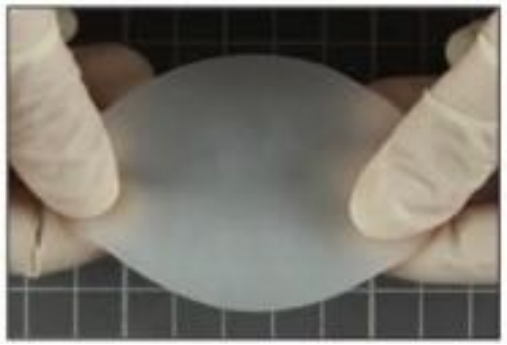
GREEN ART PROJECT

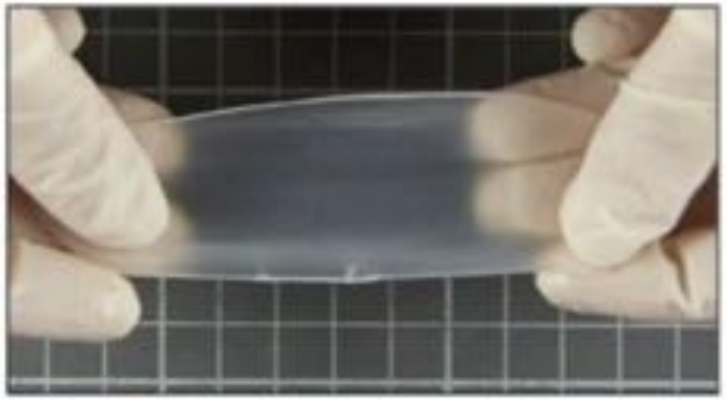
Green technologies and materials for Cultural Heritage Conservation



Green technologies and materials for Cultural Heritage Conservation

FREEZING





- **Highly retentive PVA hydrogels**
- **PEGGY FAMILY**

Green technologies and materials for Cultural Heritage Conservation

The combination of active *novel* packaging materials, developed basing on materials modelling, with sensors and wireless sensor technologies (WST) may provides smart, low-cost easy-to-deploy systems for storage and exhibition of artefacts.

display cases

storage crates

archive boxes

Green technologies and materials for Cultural Heritage Conservation

NOVEL MATERIALS FOR PRESERVATION OF CULTURAL HERITAGE

Different materials have been developed to create a stable environment, and limit temperature and relative humidity variation.

- **Modified-corrugated cardboards** with enhanced thermal performances: they can stabilize temperature and relative humidity exploiting the potentials of **polymer composites** (PCMs and Silica Aerogels). These composites show ease of preparation and deposition on corrugated cardboards, good adhesion, low shrinkage after water evaporation and no significant aesthetical alterations

- **Boards coated with Polyvinylalcohol membranes** (PVA) and **Super Absorbent Polymers** (SAPs) able to regulate RH (photo).

- **High-quality graphene membranes** as a protective coating for humidity protection on artwork. The graphene veil absorbs the UV light and delays the diffusion of oxidizing species.

Green technologies and materials for Cultural Heritage Conservation

GREEN &SUSTAINALBE SYNTHESIS

GREEN GELS VOCs adsorbers

- Affordable
- Scalable up
- **Simple, easy, clean**
- Atom economy: 100%*
- **E-Factor: 0.3****
- Castor oil derived from **non-edible beans*****

	€ kg^{-1}
Castor oil	3-5.5
PDI	15-25
ZnO	3-5

* Kg (MW) product/kg (MW) reagent

** Kg waste/kg product

EP/PCT

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814496

VOCs control

Peggy Guggenheim

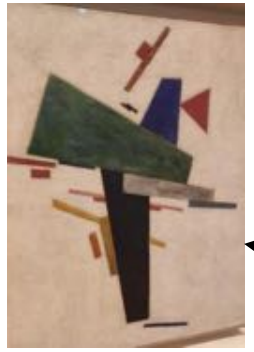
1. Zuliani, A.; Bandelli, D.; Chelazzi, D.; Giorgi, R.; Baglioni, P. Environmentally friendly ZnO/Castor oil polyurethane composites for the gas-phase adsorption of acetic acid. *Journal of Colloid and Interface Science* **2022**, *614*, 451-45 OI: 10.1016/j.jcis.2022.01.123.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814496

Green technologies and materials for Cultural Heritage Conservation

Kazimir Malevich – **Untitled** – 1916

BEFORE VOCs Adsorber ***ca.*** **2.5-3 ppm**
AFTER 1 months VOCs Adsorber ***ca.*** **1.5-2 ppm**
AFTER 2 months VOCs Adsorber ***ca. 0.5*** **ppm**



Vasily Kandinsky– **Upward** – 1929

BEFORE VOCs Adsorber *ca.* **1.5-2 ppm**
AFTER 1 month VOCs Adsorber **less than 0.5 ppm**
AFTER 2 months VOCs Adsorber **less than 0.5 ppm**

El Lissitzky - **Untitled –** 1919/20

BEFORE VOCs Adsorber *ca.* **1.5-2 ppm**
AFTER 1 month VOCs Adsorber **less than 0.5 ppm**
AFTER 2 months VOCs Adsorber **less than 0.5 ppm**

BEFORE VOCs Adsorber ***ca. 7*** **ppm**
AFTER 1 month VOCs Adsorber **2.4 ppm**

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814496

Adsorption capacity

A simple calculation based on the amount of acetic acid released by a work of art (for example Boccioni at Peggy Guggenheim, Venice) a foil of 500 grams of ibrid gel should protect the work for about

100 years

Umberto Boccioni
Dinamismo di un cavallo in corsa + case, 1915
Guazzo, olio, legno, cartone, rame e ferro dipinto, 112,9 x 115 cm

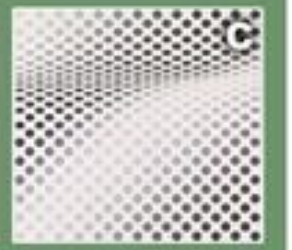
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 814496

Green technologies and materials for Cultural Heritage Conservation

GELS AND CLEANING FLUIDS
(RC[a] - TRL 9)

Canvas and easel paintings

Removal of dust and grime or aged varnishes that altered the original colours of the painting. **Paint layers are water-sensitive!**



COSOLIDANTS
(RC[a] - TRL 3-4)

Textiles, canvas supports, paper, stone

Consolidation is performed while maintaining artefacts' original appearance and properties. **Fragile/sensitive paint layers!**

PACKAGING MATERIALS GREEN TECH SENSORS
(PC[a] - TRL 3-4)

Storage deposits, archive boxes and crates, display cases

Solutions must be feasible and cost-effective also for large storages (> 1000 items)

COATINGS
(RC[a] - TRL 3-4)

Metal, stone

After removal of alteration layers, protection against corrosion, T, RH is granted while maintaining artefacts' original appearance and properties

GREEN ART PROJECT
2022-2025

Green technologies and materials for Cultural Heritage Conservation

The European Commission is acknowledged for funding

NANORESTART, NANOFORART, INNOVACONCRETE, APACHE, GREEN ART (2022-2025)

These projets generated new **groundbreaking materials and methods** (so far about 50 from CSGI) based on **nanoscience** for the conservation of our HERITAGE

Many are already available to restorers

Thanks for your attention!

Piero Baglioni

CSGI and University of Florence

baglioni@csgi.unifi.it

www.csgi.unifi.it