2018 ANNO EUROPEO DEL PATRIMONIO CULTURALE #EuropeForCulture

DSCTM

NanoRestART

Horizon 2020 European Union Funding for Research & Innovation

CNR ISMN
ISTITUTO PER LO STUDIO DEI MATERIALI NANOSTRUTTURATI

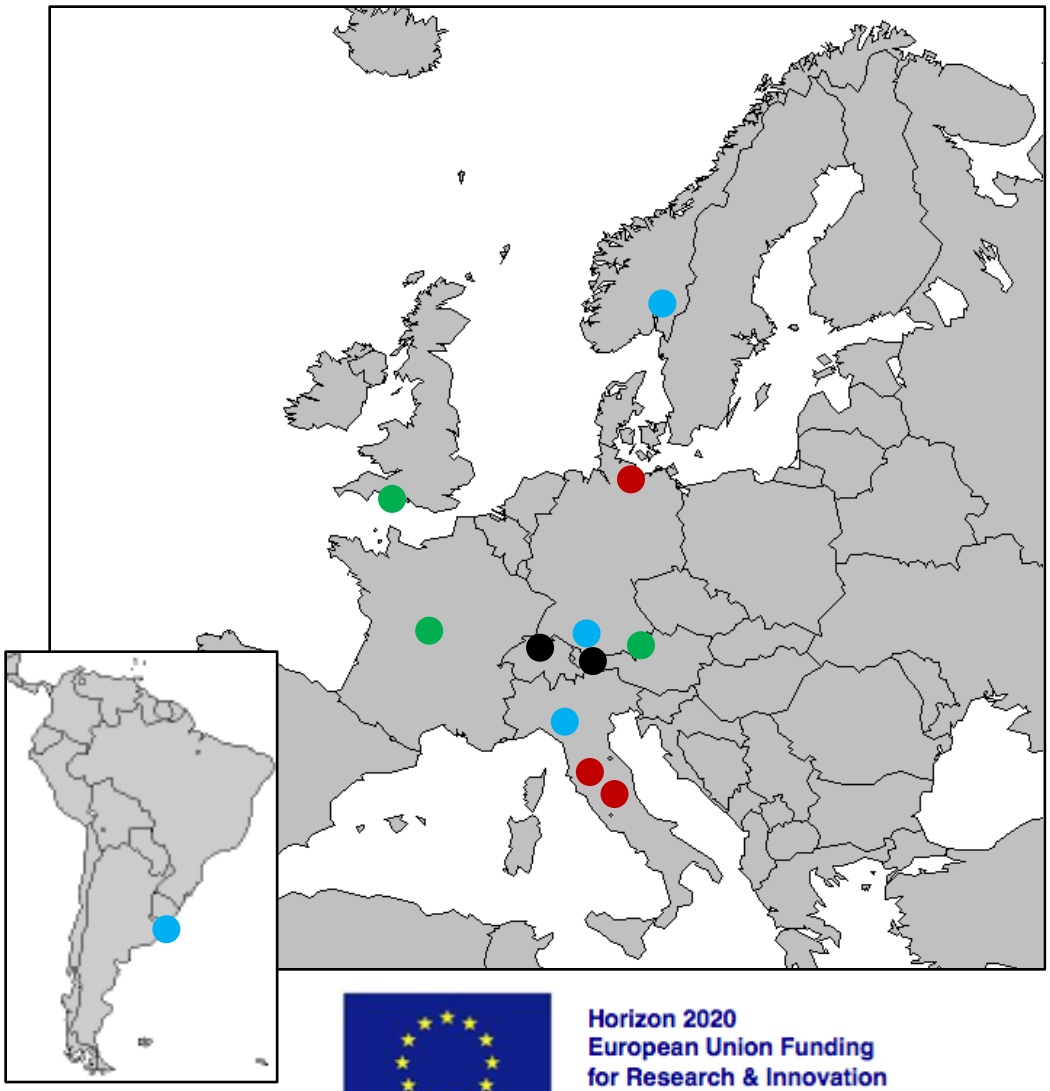
Conferenza di Dipartimento 2018, Assisi 24-26 settembre

CNR-DSCTM YIA2018-Chimica per i Beni Culturali

Rivestimenti multifunzionali per una protezione efficace e duratura di opere d'arte moderna in metallo

Chiara Giuliani

NANORESTART – NANOmaterials for the RESToration of works of ART -



Rivestimenti protettivi attivi

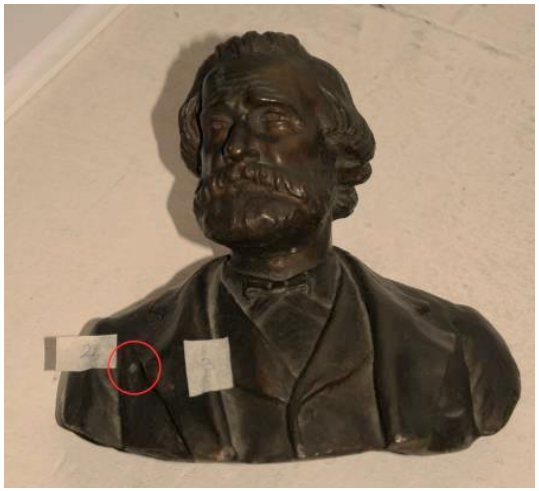
Nanocomposti attivi

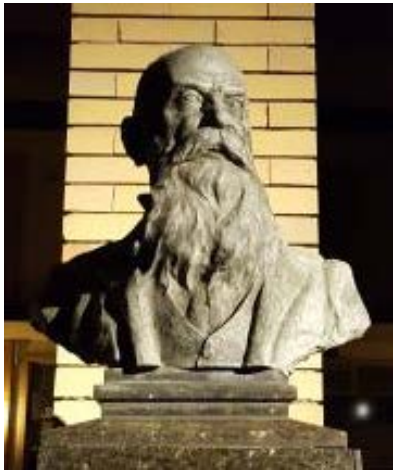
Rivestimenti protettivi passivi

Conservatori

Horizon 2020
European Union Funding
for Research & Innovation

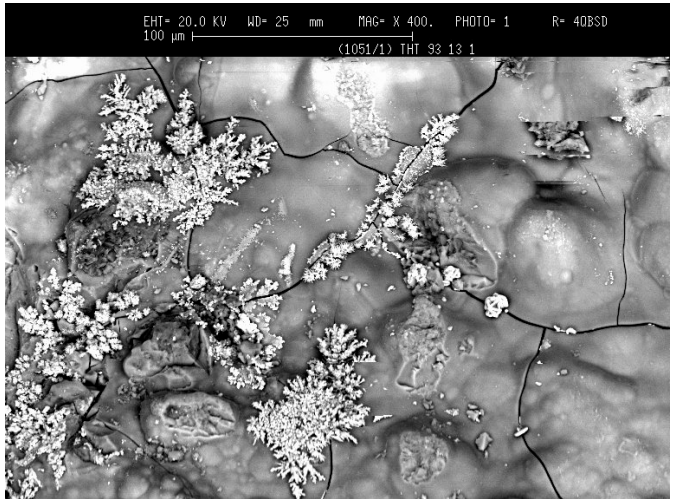
Opere d'arte moderna in bronzo



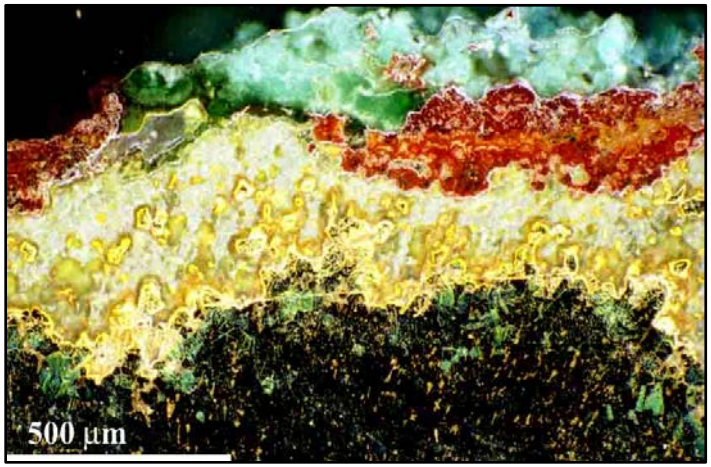


(Giò Pomodoro)

Fenomeni degradativi indotti da cloruri



$CuCl_2 \cdot 3Cu(OH)_2$



Atacamite $Cu_2(OH)_3Cl$

Cuprite Cu_2O

Nantokite CuCl

at RH> 35 %

1) $4CuCl + 4H_2O + O_2 \rightarrow CuCl_2 \cdot 3Cu(OH)_2 + 2HCl$

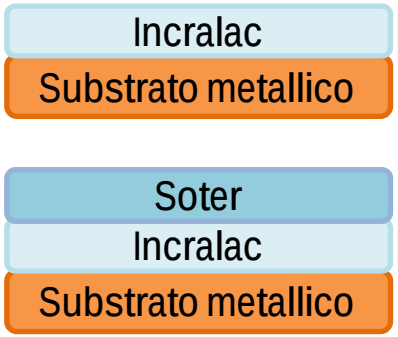
2) $2Cu + 2HCl \rightarrow 2CuCl + H_2$

Il rame è continuamente consumato e trasformato in una polvere verde di $Cu_2(OH)_3Cl$ (atacamite e polimorfi)

Prodotti commerciali

- Resine acriliche addizionate con benzotriazolo (Incralac)

- Cere microcristalline addizionate con benzotriazolo (Soter)



Henry Moore

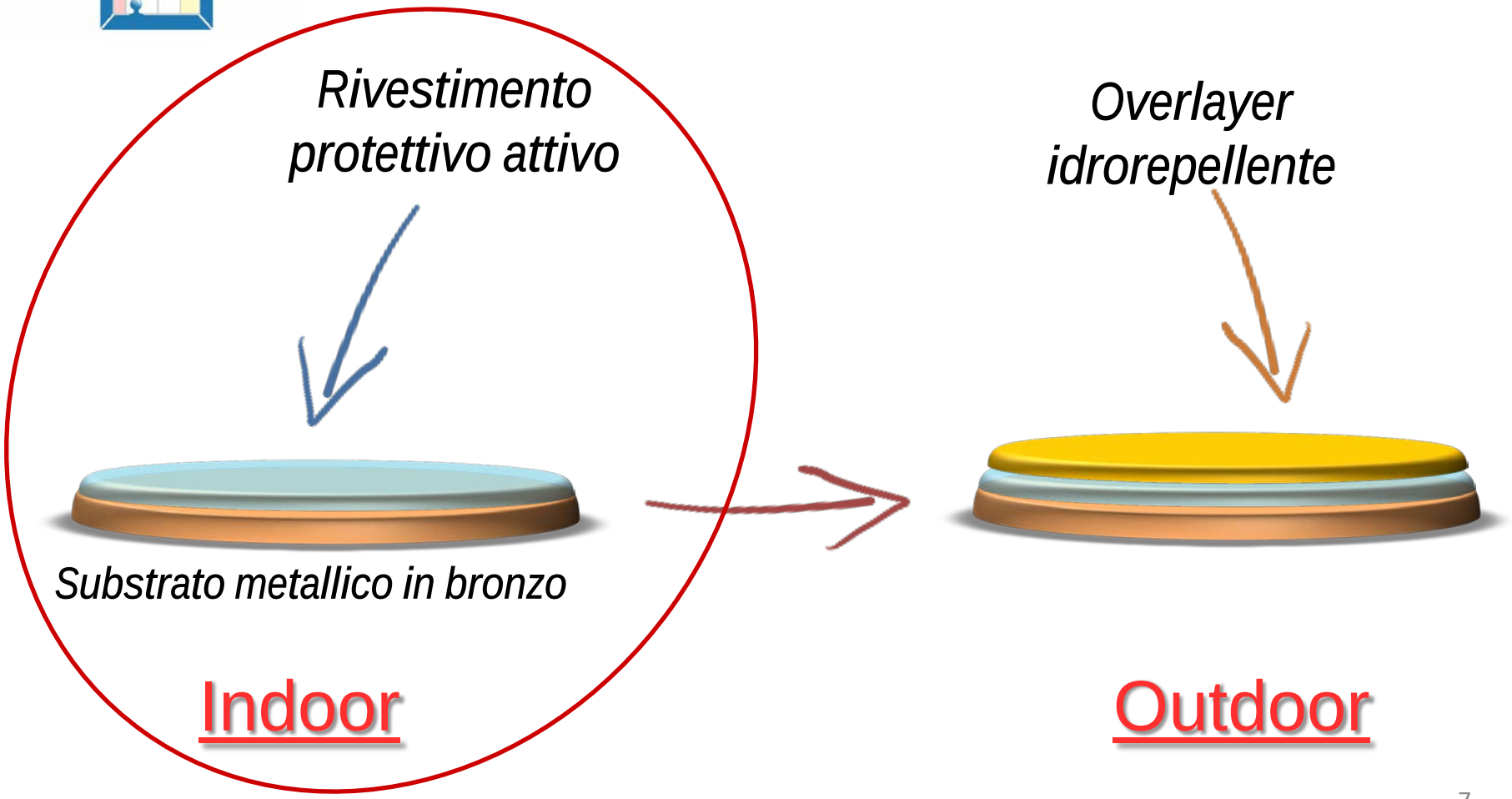
Criticità:

-Tossicità (inibitore e solventi)
-Alterazione dell'aspetto (es. opacizzazione)
-Removibilità
-Efficacia prolungata

Obiettivi dell'attività di ricerca

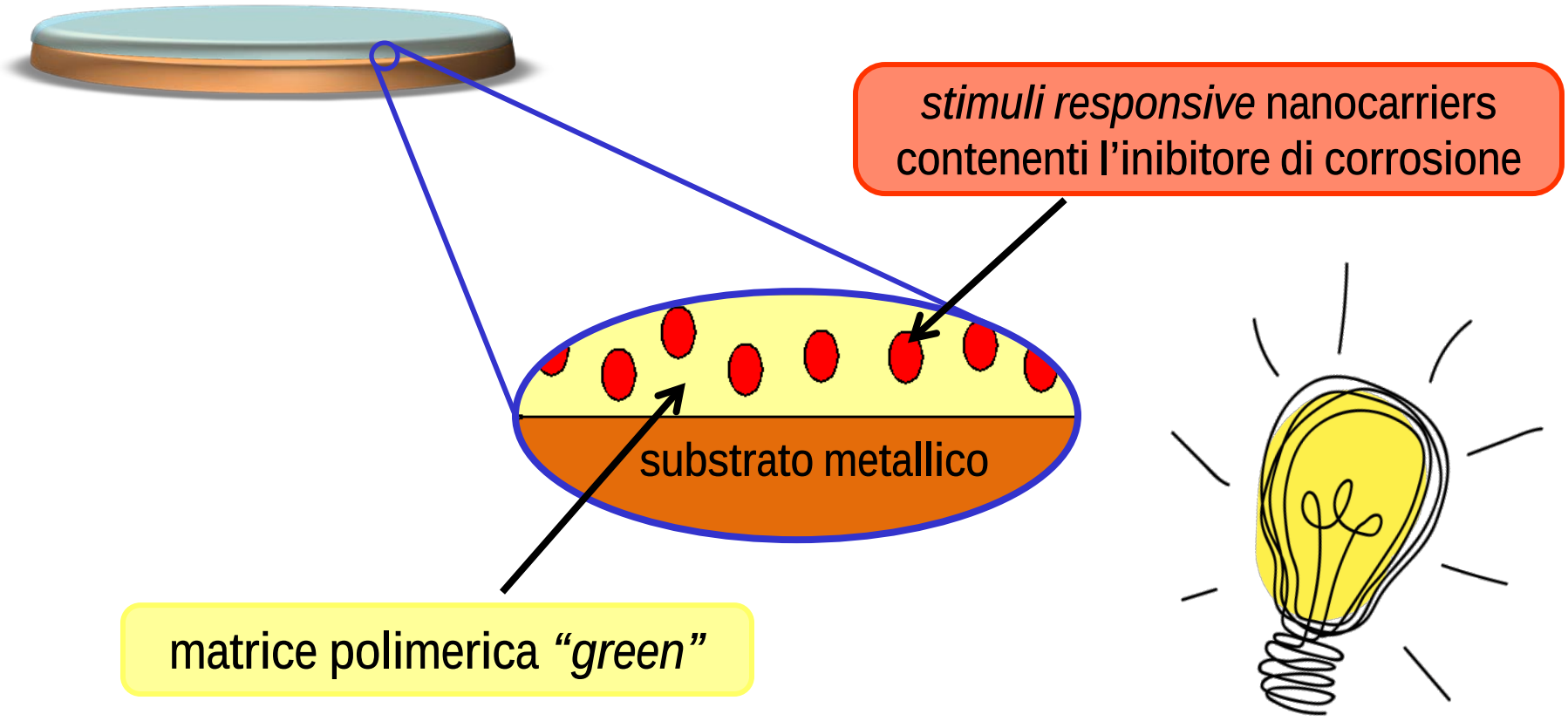
- Nuovi approcci con azione locale e mirata
- Materiali e metodi più sostenibili e sicuri
- Trasparenza
- Rimovibilità
- Elevata capacità protettiva

Strategia generale



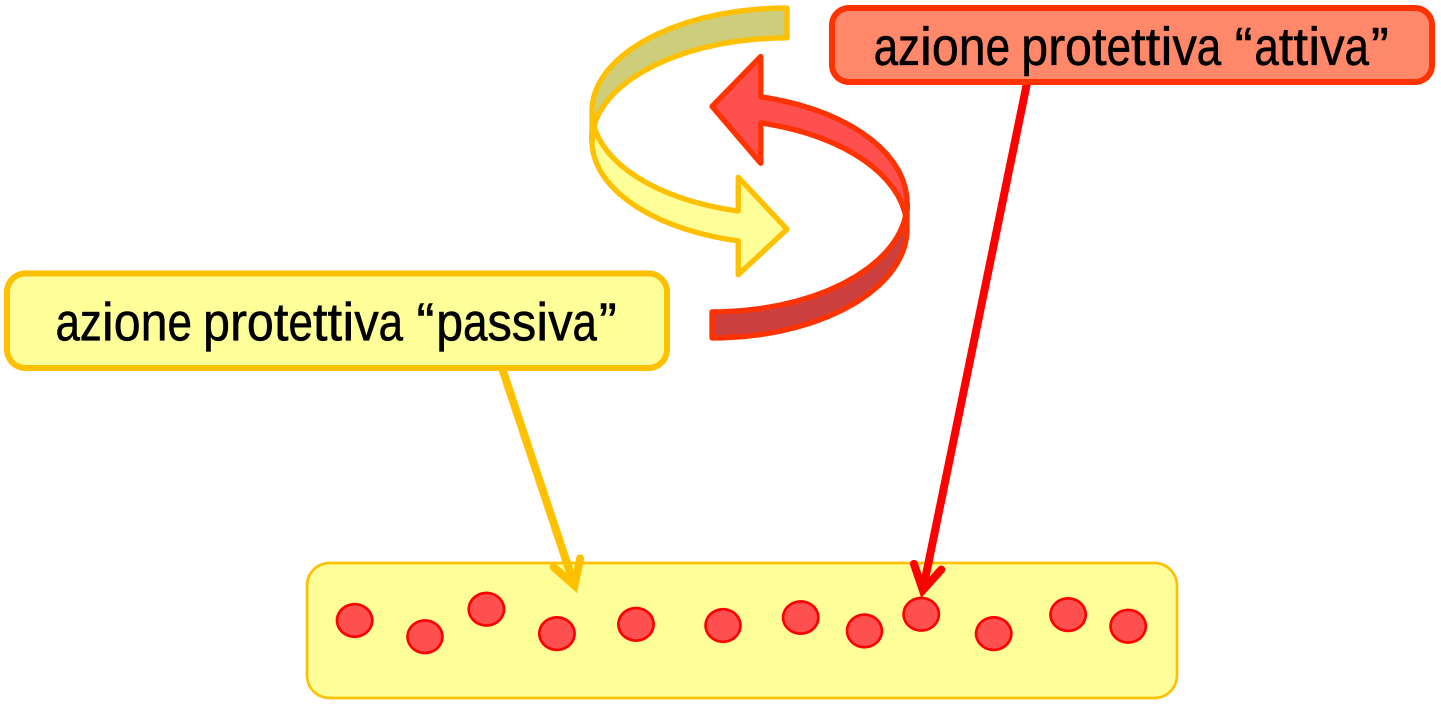
Rivestimenti multifunzionali per la protezione di opere d'arte moderna in bronzo

Rivestimento attivo: approccio multifunzionale



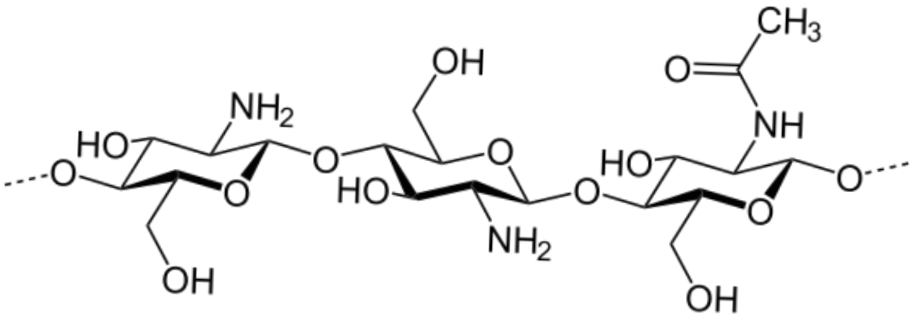
Rivestimenti multifunzionali per la protezione di opere d'arte moderna in bronzo

Azione combinata



Rivestimenti protettivi a base di chitosano

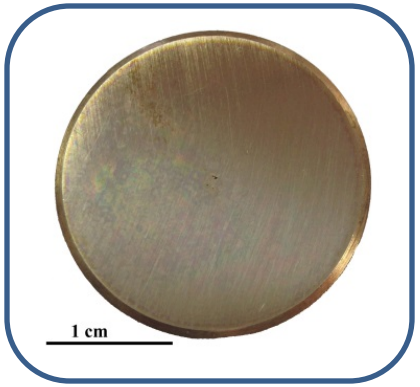
- Biodegradabile e biocompatibile
- Derivante da fonti rinnovabili
- Buone capacità di *film forming*
- Buona adesione su superfici metalliche
- Trasparente
- Antimicrobico
- Solubile in soluzione acquosa

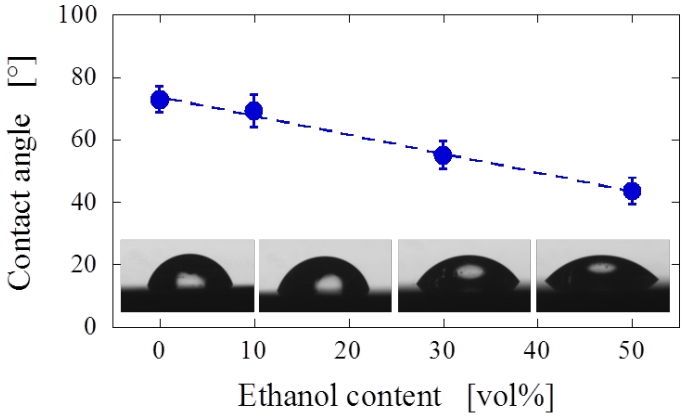


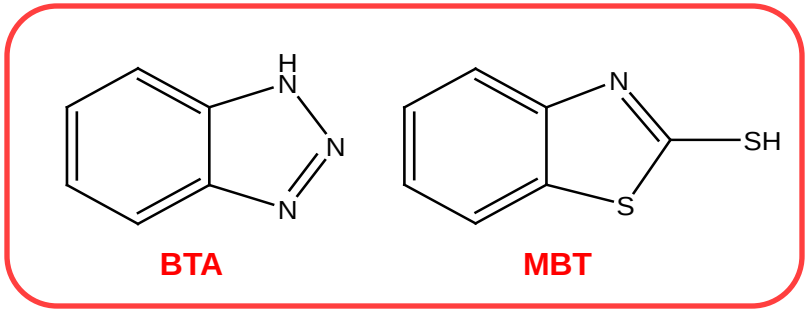
Facilmente applicabile e removibile con solventi non tossici

Ottimizzazione delle formulazioni a base di chitosano

- miscela solvente: H_2O/EtOH 50/50 vol/vol
- additivo ottimale per la dissoluzione del chitosano
- aggiunta degli inibitori di corrosione
- Spessore



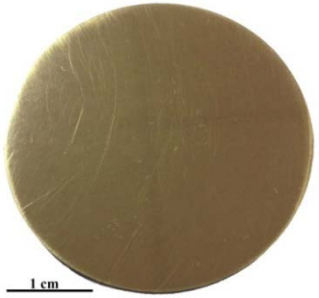




Progress in Organic Coatings 122, 138-146 (2018)

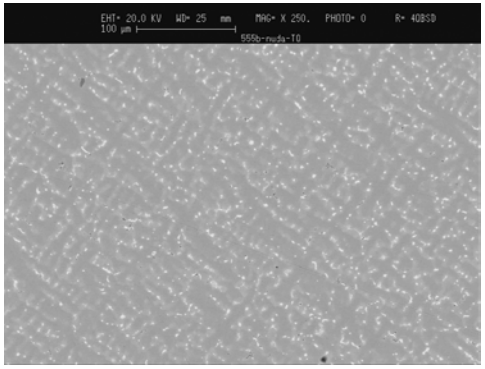
Validazione dei rivestimenti protettivi a base di chitosano

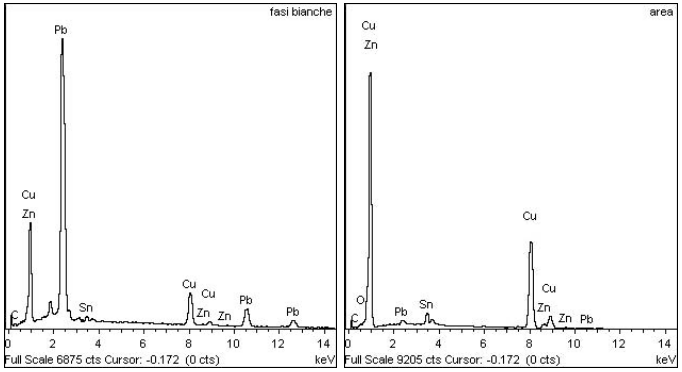
- Scelta di una lega quaternaria rappresentativa come substrato modello



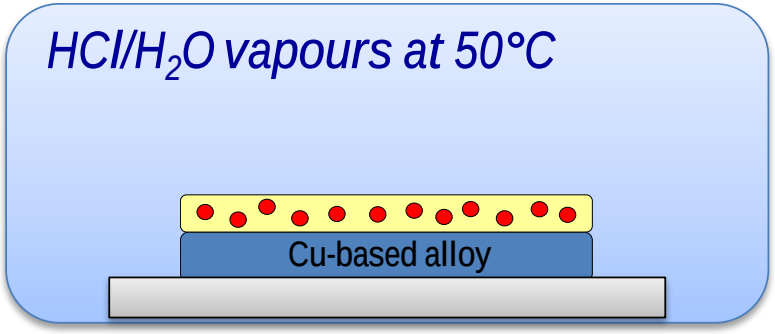
Cu 85%, Sn 5%, Zn 5%, Pb 5%

(analisi EDS: Cu 86.6%, Sn 6.5%, Zn 4.4%, Pb 2.5%)





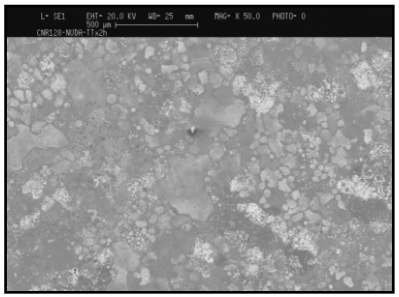
- Messa a punto di appropriati test accelerati di corrosione in presenza di vapori acidi



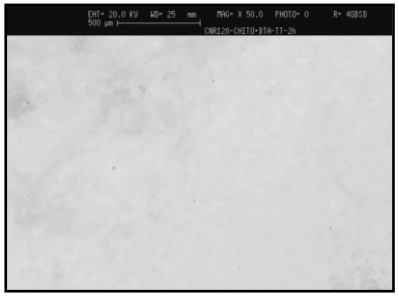
Rivestimenti protettivi a base di chitosano

Dopo trattamento accelerato di corrosione

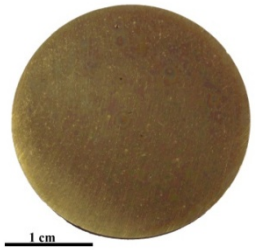
Lega nuda

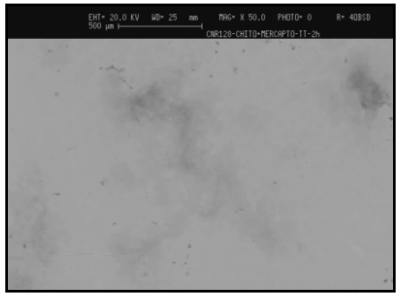


Chitosano-BTA

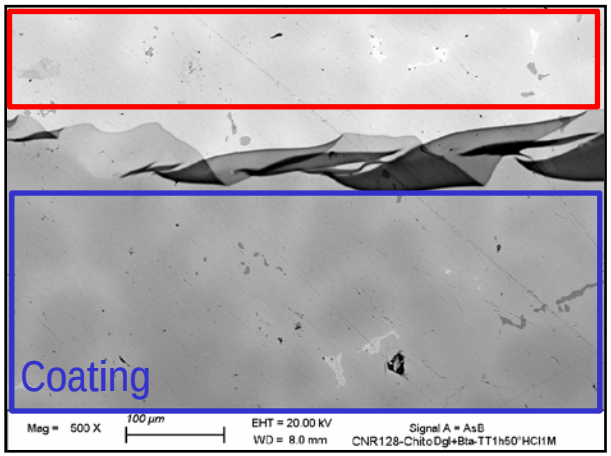


Chitosano-MBT





Removed coating

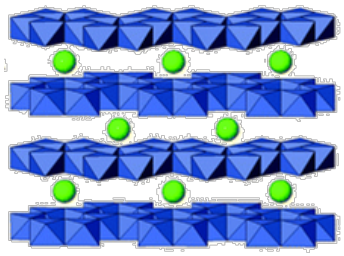


- ✓Effetto protettivo sulla lega.
- ✓Soddisfano i requisiti estetici necessari per l'applicazione nel campo dei beni culturali
- ✓Effetto sinergico tra il chitosano e l'inibitore

Progress in Organic Coatings 122, 138-146 (2018)

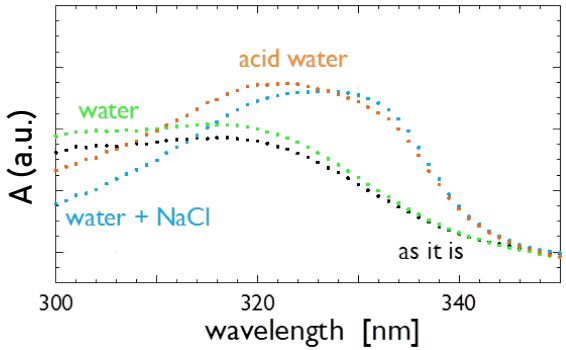
Stimuli responsive nanocarriers

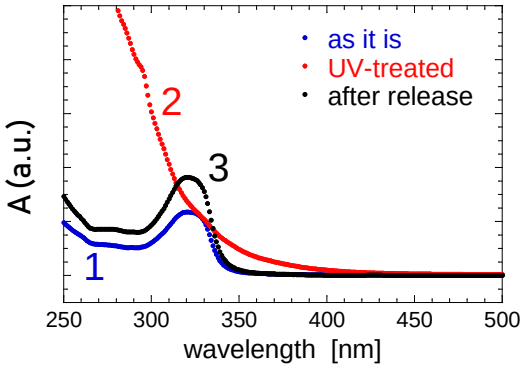
Layered Double hydroxides (LDH)



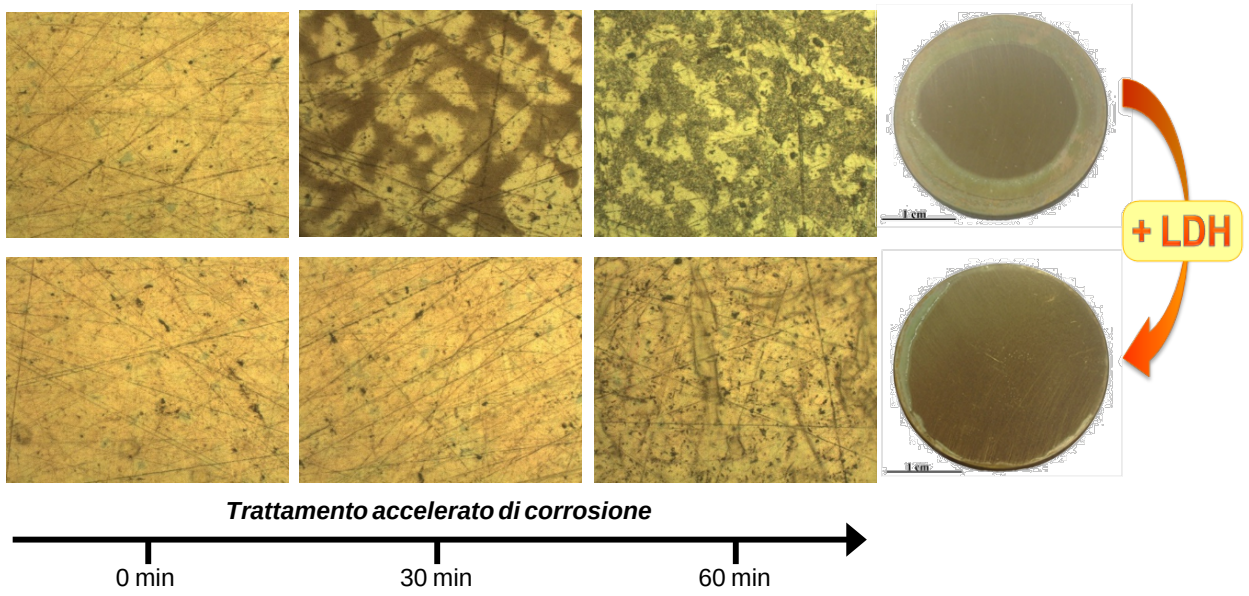
inhibitor (anionic)

- Rilascio controllato indotto da stimoli esterni (Cl^-, variazioni di pH)
- Protezione dell'inibitore dalla fotodegradazione





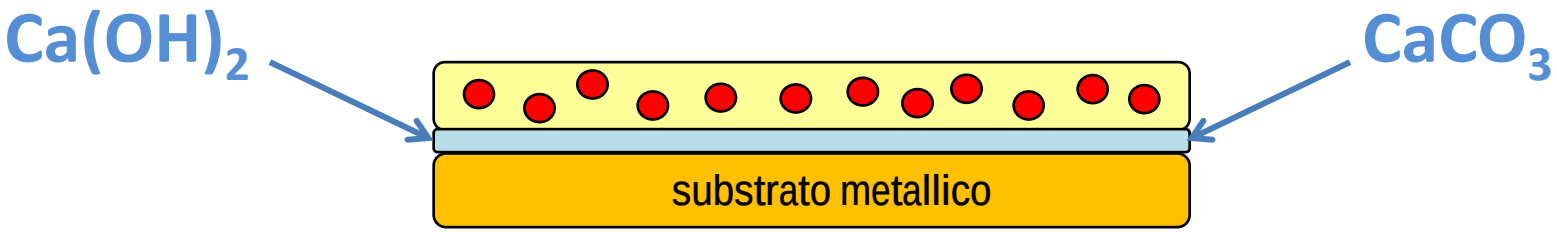
Aumento dell'efficacia protettiva nel tempo



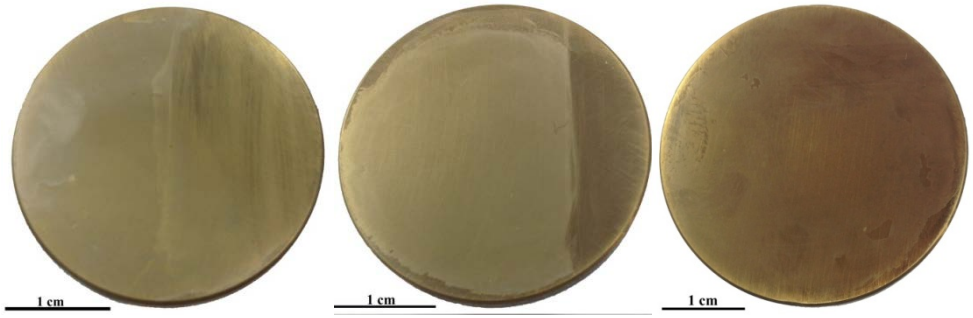
Angewandte Chemie International Edition 57 (25), 7380-7384 (2018)

Ottimizzazione dei rivestimenti protettivi a base di chitosano

- **Nanoparticelle alcaline**



✓ La quantità di nanoparticelle alcaline è stata ottimizzata in modo da non alterare l'aspetto della lega.



Nanoparticelle di $Ca(OH)_2$ preparate dal CSGI

Ottimizzazione dei rivestimenti protettivi a base di chitosano

- **Nanoparticelle alcaline**

Dopo 18 h di trattamento accelerato di corrosione

chitosano-BTA

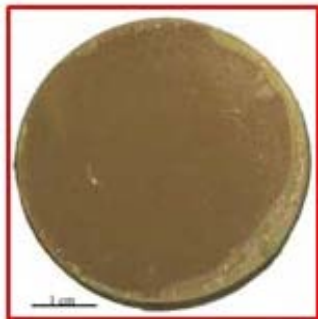
1. $CaCO_3$
2. chitosano-BTA

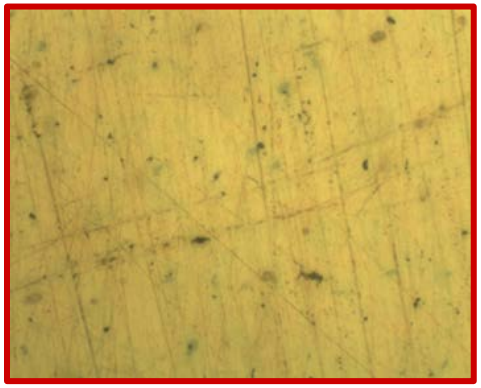
1. Ca(OH)2
2. chitosano-BTA

Effetto positivo delle nanoparticelle alcaline sull'efficacia protettiva

Rivestimenti protettivi a base di chitosano: formulazione ottimizzata

Chitosano - $Ca(OH)_2$- BTA - LDHs



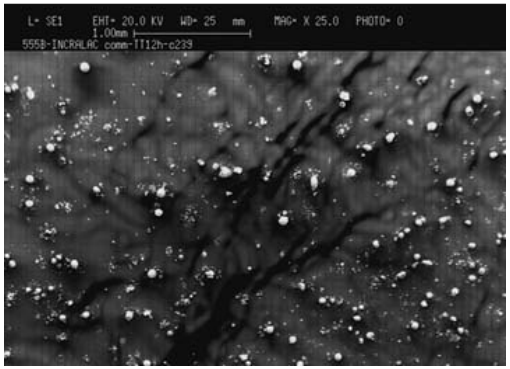


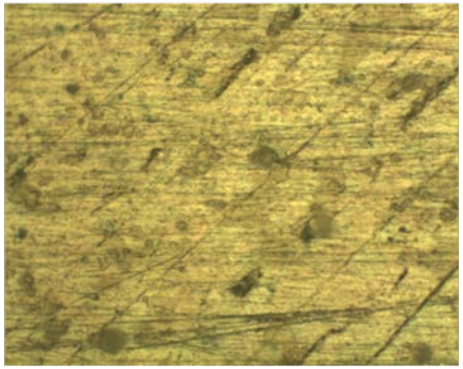
21 h di trattamento accelerato di corrosione

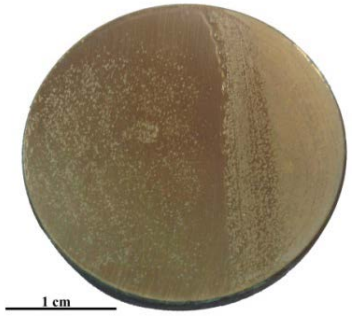
chitosano-BTA

9 h di trattamento accelerato di corrosione

Riferimento commerciale (incralac)

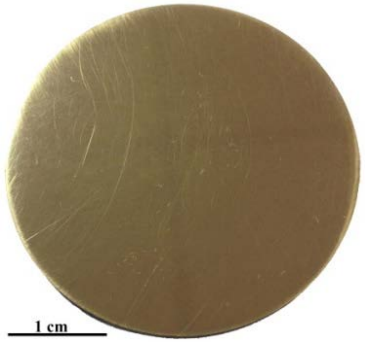




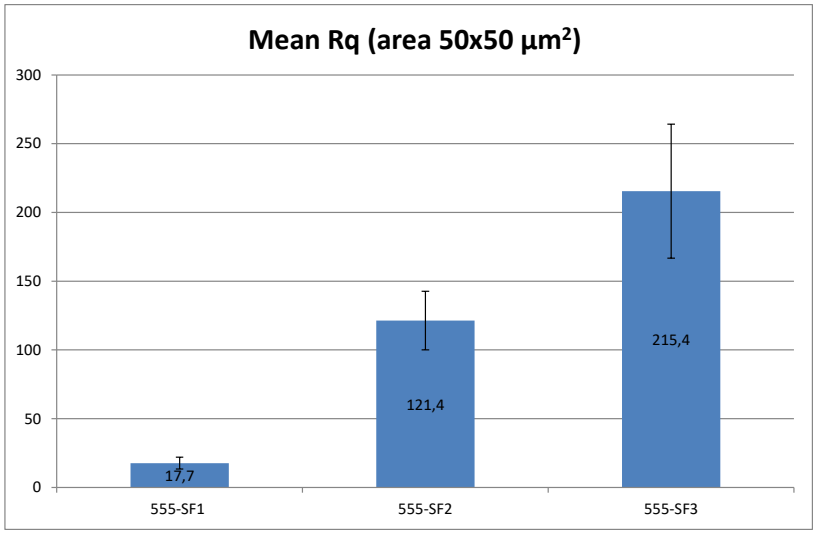


9 h di trattamento accelerato di corrosione

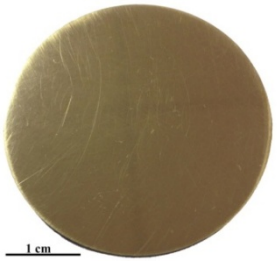
Substrati modello: finitura superficiale



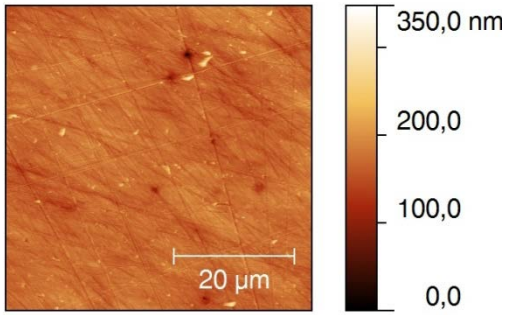
Cu 85%, Sn 5%, Zn 5%, Pb 5%



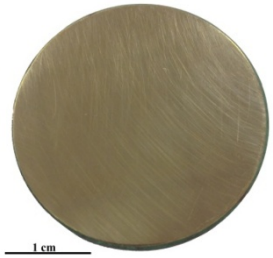
555-SF1



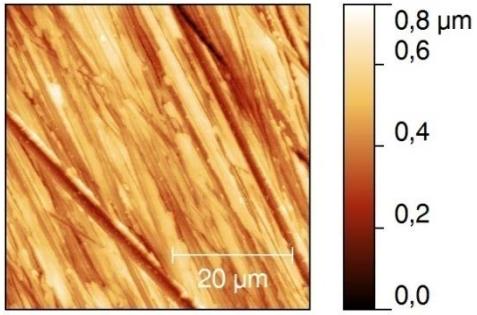
Rq 17,7 nm



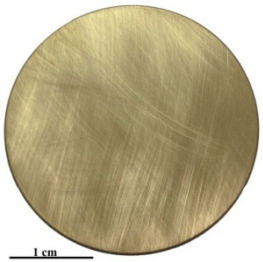
555-SF2



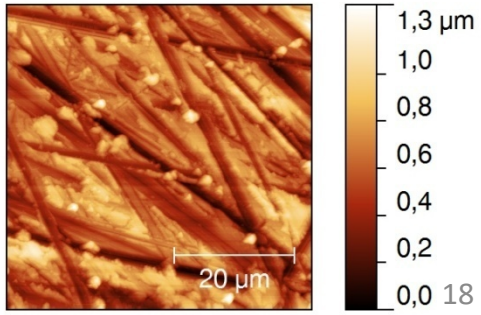
Rq 121,4 nm



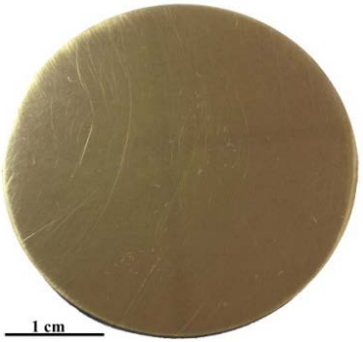
555-SF3



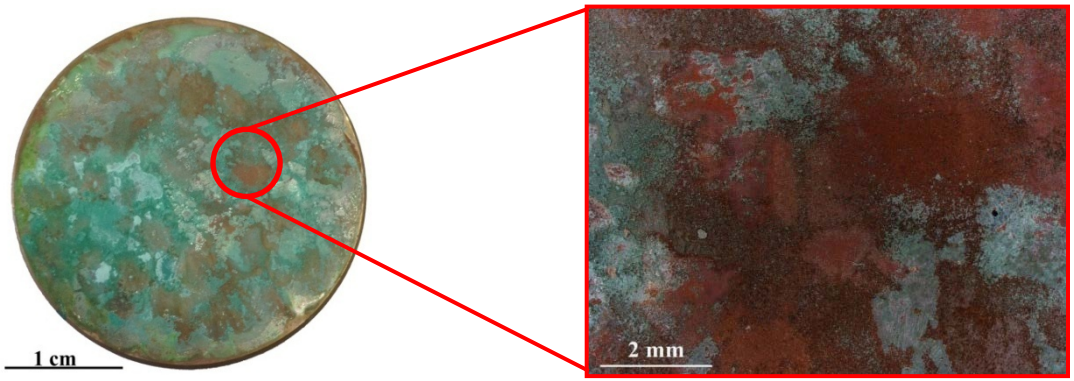
Rq 215,4 nm

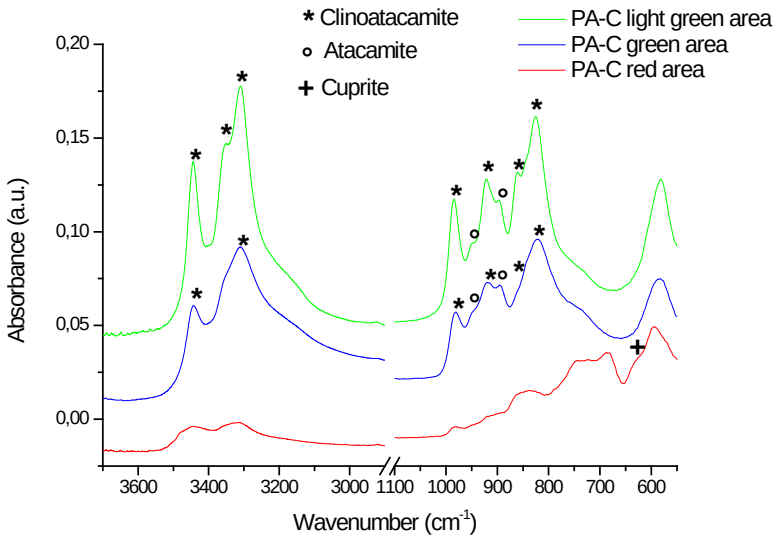


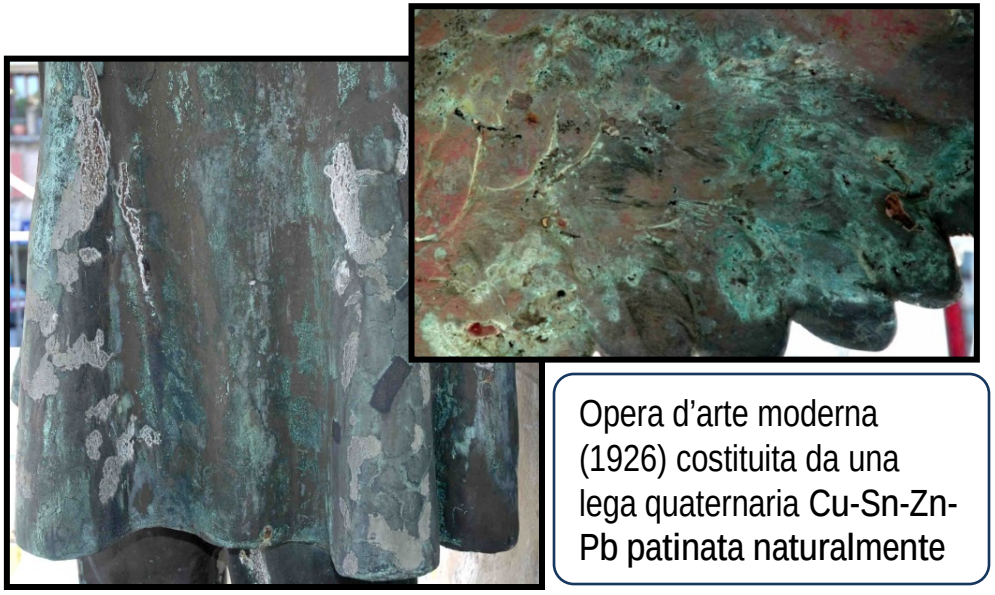
Substrati modello: patine artificiali



Cu 85%, Sn 5%, Zn 5%, Pb 5%



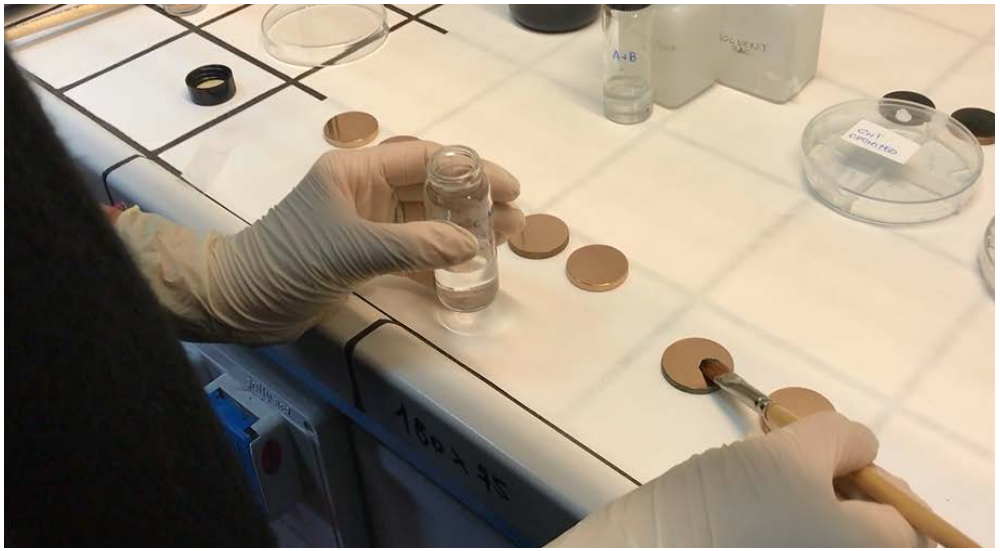




Opera d'arte moderna (1926) costituita da una lega quaternaria Cu-Sn-Zn-Pb patinata naturalmente

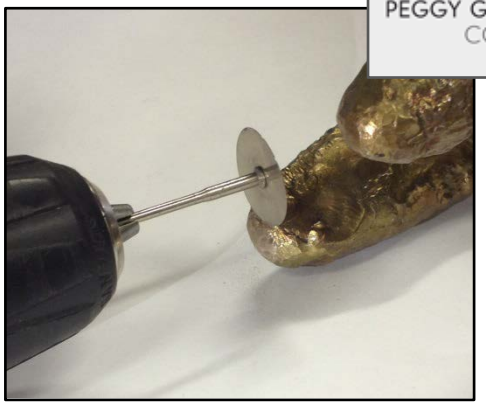
Applied Surface Science 421, 120–127 (2017)

Validazione in collaborazione con i conservatori



ACCADEMIA DI BELLE ARTI DI BRERA

Applicazioni su casi di studio: “Chimera” di Mirko Basaldella



Cu 93,2%, Sn 5,5%, Zn 1,3% (EDS)

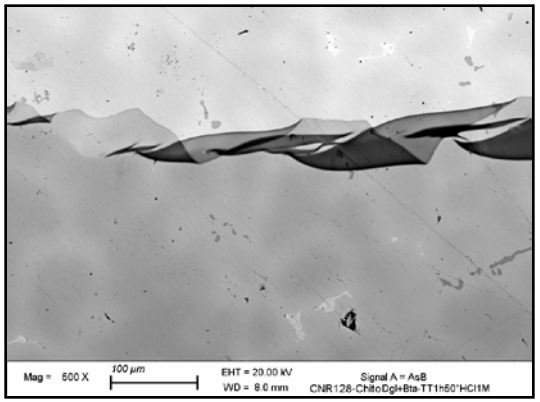
Con la collaborazione di Stefano Lanuti

✓ I coatings soddisfano i requisiti estetici

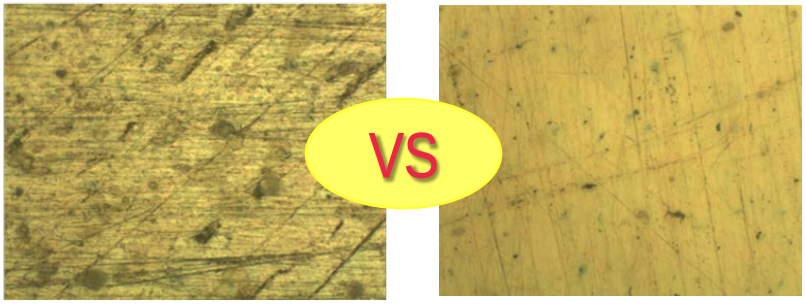
Conclusioni...

Performance superiori rispetto ai prodotti commerciali:

- ✓Trasparenza
- ✓Removibilità
- ✓Alta capacità protettiva
- ✓Sicurezza per l'operatore e sostenibilità



Prodotto commerciale **formulazione ottimizzata a base di chitosano**



9 h **21 h**

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