EVALUATING THE EFFICACY OF SILICA NANO-PARTICLE "LIQUID GLASS" PROTECTIVE COATINGS FOR OUTDOOR MARBLE SCULPTURE AND MONUMENTS

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ABSTRACT

"Liquid glass" products have been proposed by manufacturers for use as inert and versatile coatings, consisting of silica nano-particles held to various substrates without adhesives or binders to various substrates. By creating a nanoscopic surface texture, they emulate the "lotus effect", providing increased hydrophobicity, oleophobicity, water vapor permeability, anti-microbial properties, and "easy to clean" qualities. Conservators and conservation scientists have not yet extensively tested these coatings, and thus further research may determine their suitability and ascertain possible applications in the conservation field. This research analyzed three coatings for potential use for the preservation of stone architecture, sculpture, and monuments.

PREP

Products Tested

1. Portol Pro (Cenano GmbH & Co. KG)
2. Stone Finish (NanoPool GmbH)
3. 2 Part AntiGraffiti (NanoPool GmbH)

Substrate

- Olympia White marble from Navy Memorial Monument
- Also tested surfaces previously coated with Graffiti Solution System product
- Sanded to 130 grit
- 91% calcite, 8% muscovite, and 1% clinochlore

Navy Memorial Monument, Ottawa

EXPERIMENTAL

Product Composition Analysis

- Fourier transform infrared spectroscopy
- Inductively coupled plasma – optical emission spectroscopy and solids content
- X-ray diffraction to determine if silica is amorphous
- Environmental scanning electron microscopy elemental analysis
- Gas chromatography mass spectroscopy to identify potential organic components

Surface Morphology and Aesthetic Change

- Optical microscopy, UV Fluorescence
- Environmental scanning electron microscopy
- Colorimetry measurements
  - Before and after application
  - After 5 days at 50°C and 60% RH
  - After 5 days at 200°C

Water Repellence and Vapor Permeability

- Water contact angle measurements
- Water absorption (RILEM Tube Test
- Water Vapor Transmission Rates

Graffiti and Coating Removal

- Evaluate ease of graffiti removal
- Investigate removability of coatings

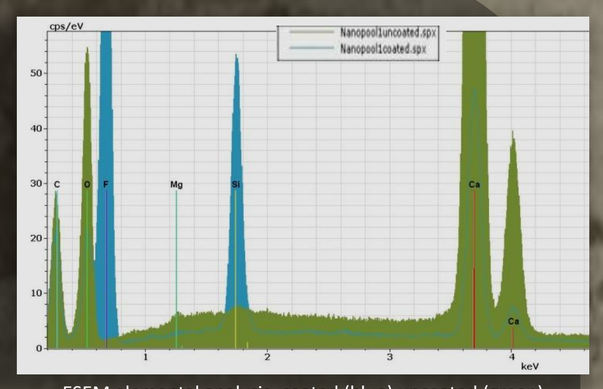
CONCLUSIONS

These products show potential for use in conservation, and may prove useful as a protective layer from surface dirt, pollution, and graffiti than as water repellents. Future research is necessary on these products, and could investigate: prevention of biodeterioration, long term stability and reapplication, removability, re-treatability, and use on other substrates.

RESULTS

Product Composition Analysis

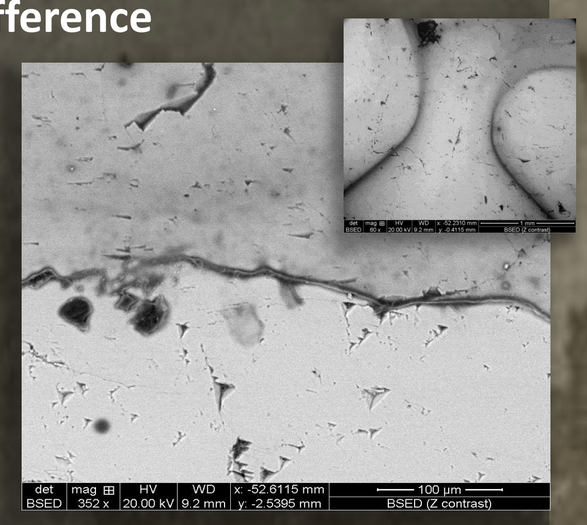
- Likely contain a perfluoropolymer with an amorphous silica matrix
- 0.01-0.02% of evaporated solids is Si (product 1, 2, 3 part A) 1.36% is Si in Product 3 part B



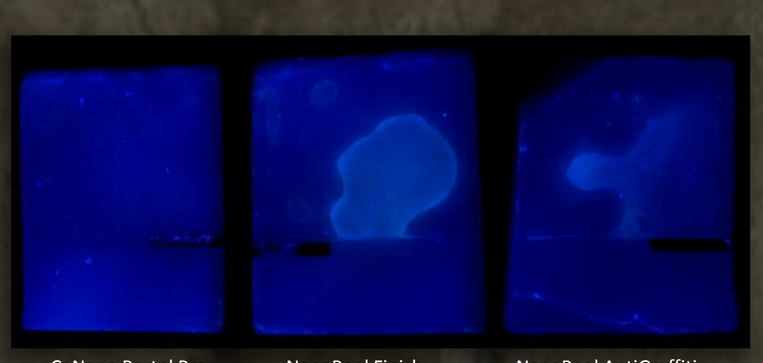
ESEM elemental analysis; coated (blue) uncoated (green)

Surface Morphology and Aesthetic Difference

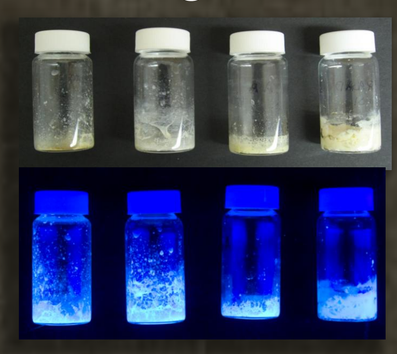
- Products 1 and 2 did not change the color of the surface with application or after aging, product increased x by x
- Tape lines imaged with product 2 and 3; pooled areas showed distinct increase in Si and F
- Nano-scopic surface texture not determined in ESEM, low resolution with optical microscopy
- Concentrated areas detected on surface with UV light



ESEM of Product 3, tape line
Detail: ESEm of product 3, Concentrated areas (center)



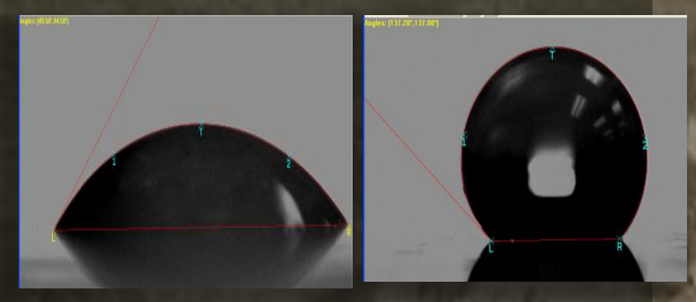
CeNano Portol Pro | NanoPool Finish | NanoPool AntiGraffiti



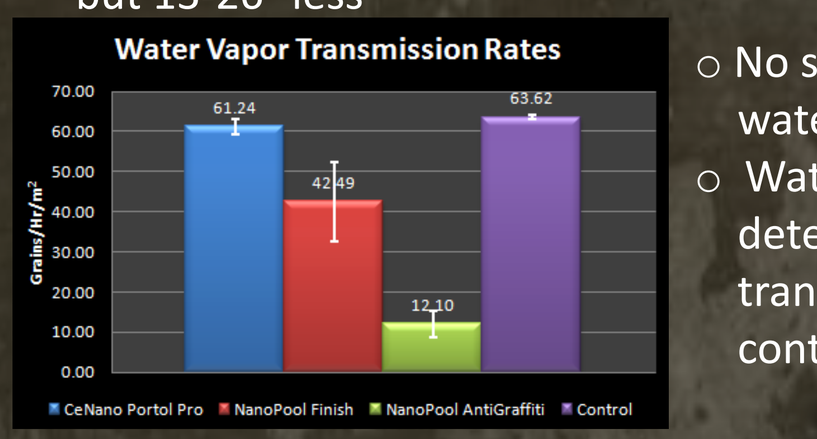
Regular reflected and UV light examination of evaporation residue

Water Repellence and Vapor Transmission

- Contact angle increased from 50.89° ± 5.33 (control) to 138.91° ± 3.00 (product 1) 138.83 ± 4.01 (product 2) 128 ± 7.55 (product 3)
- Still increased hydrophobicity on a previously coated surfaces, but 13-26° less



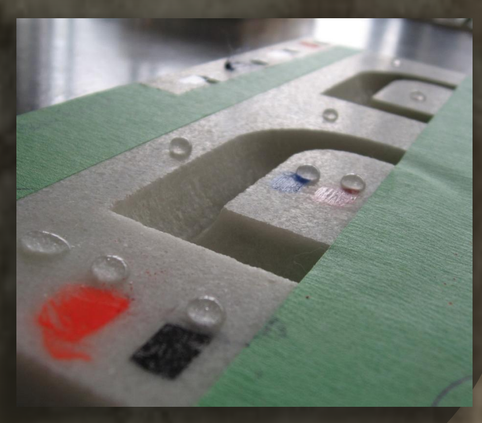
Control (uncoated) | Coated with product 1



- No significant difference in water absorption after 260 min.
- Water vapor transmission rate determined product 1's transmission rate is closest to control

Graffiti and Coating Removal

- Products improve ease of removal of graffiti
- Surface appears still hydrophobic after graffiti removal
- Soluble in hydrofluoric acid and above a pH of 13



Hydrophobicity still displayed after graffiti removal (near)
Control set (far)