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MODIFIED NANOLIME DISPERSIONS: STRUCTURE AND COLLOIDAL STABILITY

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INTRODUCTION

- Consolidation of stone, plasters and renders: lack of efficient products for calcareous substrates (e.g. limestone and lime-based mortars, Fig.1).
- *Nanolimes* (colloidal dispersions of calcium hydroxide) should overcome the limitations of traditional consolidants (e.g. limewater), but do not always guarantee a in depth consolidation.
- Research aim: evaluate the effectiveness of new nanolimes (structure, drying rate and kinetical stability).

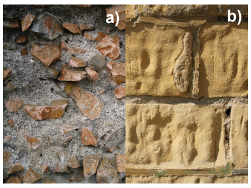

Fig. 1 - a) Roman stone masonry with lime-based mortars (Pisões Archaeological site, PT); b) masonry of Maastricht limestone (Kessel Castle, NL).

MATERIALS & TEST CONDITIONS

- New nanolimes (conc. 25g/l) synthetized by solvothermal reaction;
- Solvent modified using pure ethanol, isopropanol, butanol, water;
- New developed nanolimes applied by capillary absorption (Fig. 3b) on 4x4cm specimens of Maastricht limestone and of lime-based mortars (1:4 lime-aggregate ratio); pore size distribution presented in Fig. 2;
- Nanosize and morphology characterized by Dynamic Light Scattering (DLS) and Scanning Electron Microscopy (SEM-EDS).
- Kinetical stability studied by Uv-Vis spectroscopy (absorption at λ=600nm) and monitored over time (0 to 96h);
- Absorption and drying kinetics (50% RH; T=20º) on Maastricht limestone and lime-based mortars.

Tab. 1 – Modified nanolimes

Identification	Solvent composition
E25	100% Ethanol (EtOH)
IP25	100% Isopropanol (IpOH)
H25	100% Water (H_20)
B25	100% Butanol (BOH)

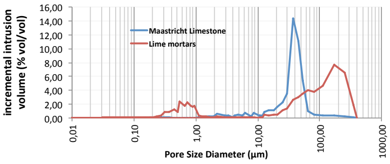

Fig. 2 - Pore size distribution of lime-based mortars (red) and of Maastricht limestone (blue).

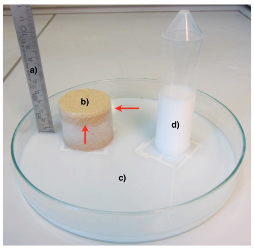

Fig. 3 - Application by capillary absorption of new Nanolimes on Maastricht limestone core specimens.

RESULTS

- Nanoparticles morphology: rounded to hexagonal shape (Fig. 4a), no significant differences when dispersed in different alcoholic solvents, but quick agglomeration in water;
- Nanosize: nano to submicrometric size (70 to 500nm, Figs. b,c), some bigger clusters of nanoparticles or unreacted metallic calcium (3-5 µm) (Fig. 4d); Nanosize of E25, IP25 and B25 remains constant over time (>96h) (Fig. 5a); H25 instead highly instable and settles in few hours (Fig. 8);
- Absorption kinetics: H25 faster compared to other nanolimes, due to higher surface tension of water (3 times higher then EtOH, IpOH or BOH) (Figs. 6a,b); Nanoparticles of B25 deposit and agglomerate at the absorption surface of Maastricht limestone; nanoparticles of H25 deposit at absorption surface of both Maastricht limestone and lime-based mortars;
- E25 and IP25 penetrate homogenously, but nanoparticles migrate back to the drying surface: the high kinetical stability and volatility of the nanolimes inhibit the phase separation of the lime nanoparticles from the alcoholic solvent.
- Drying kinetics: the solvent of the modified nanolime (E25, IP25, B25) evaporates faster compared to H25 (Figs. 7a,b).

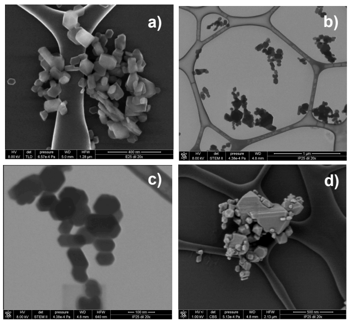

Fig. 4 - SEM-EDS microphotographs of a,b) E25 and c,d) IP25.

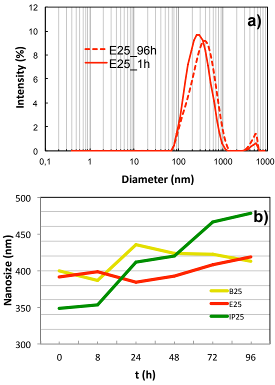

Fig. 5 - a) Nanosize distribution (DLS) after 1h and 96h of nanolime E25; b) Evolution of the nanosize over time of E25, IP25 and B25 nanolimes.

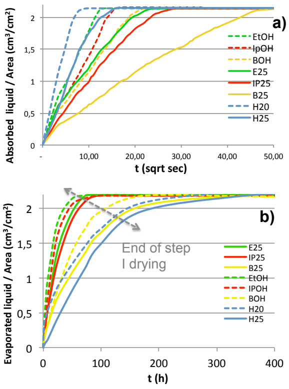

Fig. 6 - a) Absorption and b) drying kinetics of E25, IP25, B25 and H25 and their relative solvents applied on Maastricht limestone.

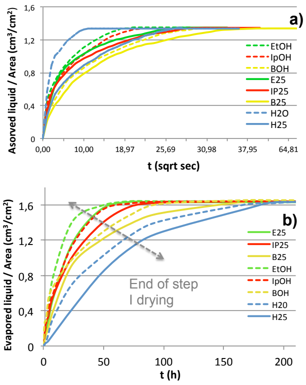

Fig. 7 - a) Absorption and b) drying kinetics of E25, IP25, B25 and H25 and their relative solvents applied on lime-based mortars.

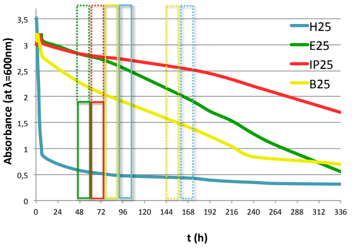

Fig. 8 - Kinetical stability of nanolimes by Uv-Vis spectroscopy; the dotted (Maastricht limestone) and solid (lime-based mortars) rectangles approximately indicate the end of the step I drying of the relative nanolimes, which corresponds to the settling of the lime nanoparticles.

CONCLUSIONS

- E25, IP25 and B25: lack of deposition of lime nanoparticles in depth in the treated material, due to the high kinetical stability of these modified nanolimes. H25: highly instable, nanoparticles end up accumulated at the absorption surface.
- Mixture of solvents appears as a promising strategy to enhance a homogeneous penetration of the nanoparticles, followed by a precipitation of the nanoparticle in the treated substrate.
- Different pore size distributions (e.g. limestone *vs* lime-based mortar) influence the drying rate of the nanolimes, and therefore the transport of the nanoparticles: it is necessary to optimize the solvent based on the properties (e.g. pore size distribution) of the material to be treated.