Helmholtz-Zentrum Geesthacht
Zentrum für Material- und Küstenforschung

Konferenzbeitrag

Scharnagl, N.:

SMARCOAT - Entwicklung smarter nano- und mikro-gekapselter Sensoren fuer Beschichtungen zur Verbesserung der Lebensdauer von Materialien

Korrosion und Korrosionsschutz von Aluminium und Magnesium,
45. Sitzung des Arbeitskreises (2016) Frankfurt / M (D), 20.-21.09.2016

DOI: -

European Commission

SMARCOAT

Entwicklung smarter nano- und mikro-gekapselter Sensoren für Beschichtungen zur Verbesserung der Lebensdauer von Materialien

(Development of Smart Nano and Microcapsulated Sensing Coatings for improving of Material Durability/Performance (ref. 645662)- MSCA-RISE-2014: Marie Skłodowska-Curie Research and Innovation Staff Exchange (RISE))

45. Sitzung des Arbeitskreises

"Korrosion und Korrosionsschutz von Aluminium und Magnesium"

20./21. September 2016

Chemetall, Frankfurt / M.

Nico Scharnagl

Helmholtz-Zentrum Geesthacht, MagIC

university of aveiro theoria poiesis praxis

ciceco centre for research in ceramics & composite materials

SMALLMATEK

synpo

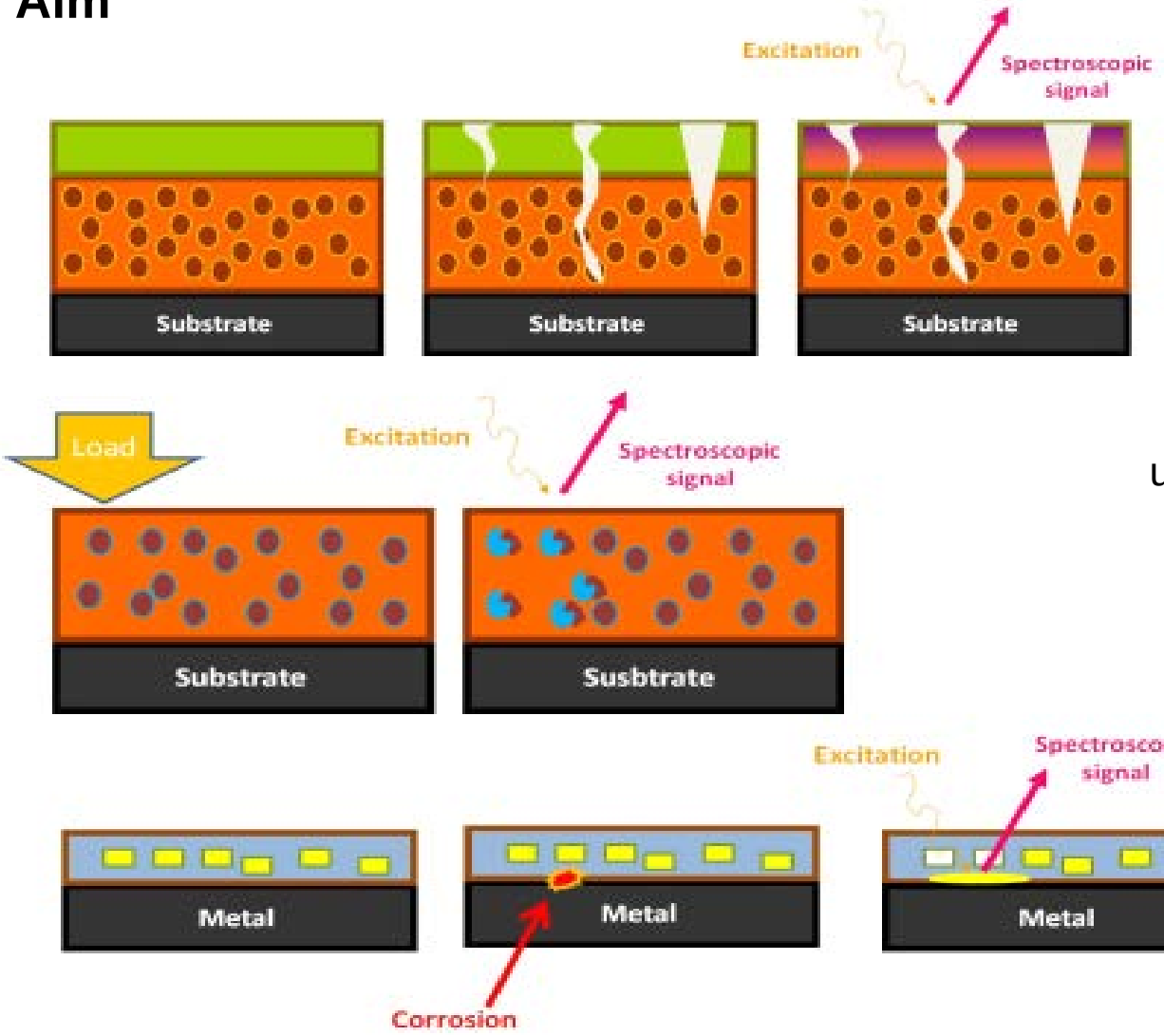
SMARCOAT

Helmholtz-Zentrum Geesthacht

Centre for Materials and Coastal Research

Description of Project

Aim



Design, synthesize, develop and upscale a set of innovative materials for sensing substrate degradation (load-carrying, corrosion) used in vehicle industry

Description of Project

Specific technical objectives are:

- ***Synthesis and characterization of micro and nanocapsules*** for controlled release of active species upon stimuli by different triggers: pH, presence of aggressive species, UV radiation, pressure.
- ***Incorporation of capsules in different coating formulations*** and characterization of sensing functionalities.
- ***Correlation between sensing and level of degradation***; optimization of coating components (capsules, coating formulations) to fine tune the desired level of detection.
- ***Study of coating properties*** considering different aspects: compatibility between components, shelf-life, pot-life, viscoeleastic/flow properties of liquid formulations.
- ***Scale up of production*** of most promising capsules and, whenever necessary scale up of coating formulation technologies (available commercially or developed in house).
- ***Industrial validation*** and standard testing.

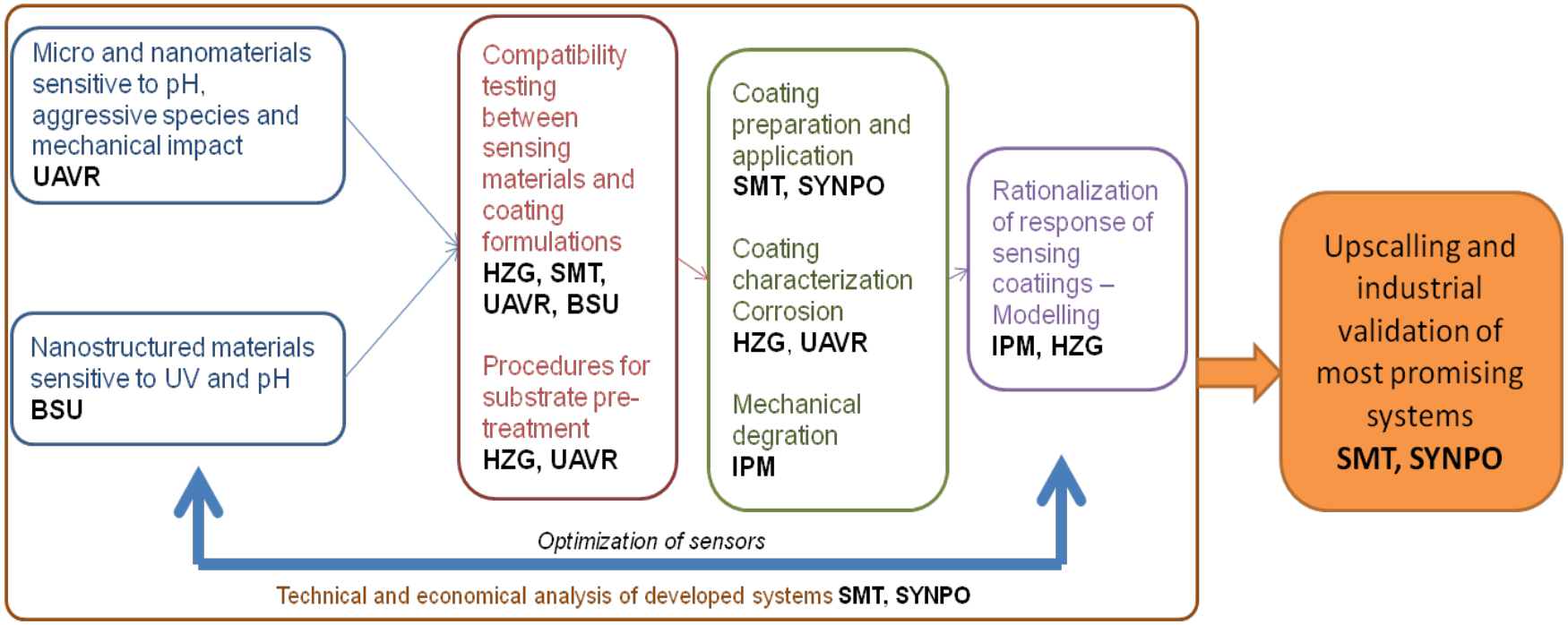
Description of Project

Partners

Partnership Member	Country
Beneficiaries	
University of Aveiro	PT
Helmholtz Zentrum Geesthacht Centre for Materials and Coastal Research GmbH	DE
Latvijas Universitates Polimeru mehanikas instituts	LV
Smallmatek Lda.	PT
SYNPO	CZ
Partner organizations	
Belarusian State University	BY

Description of Project

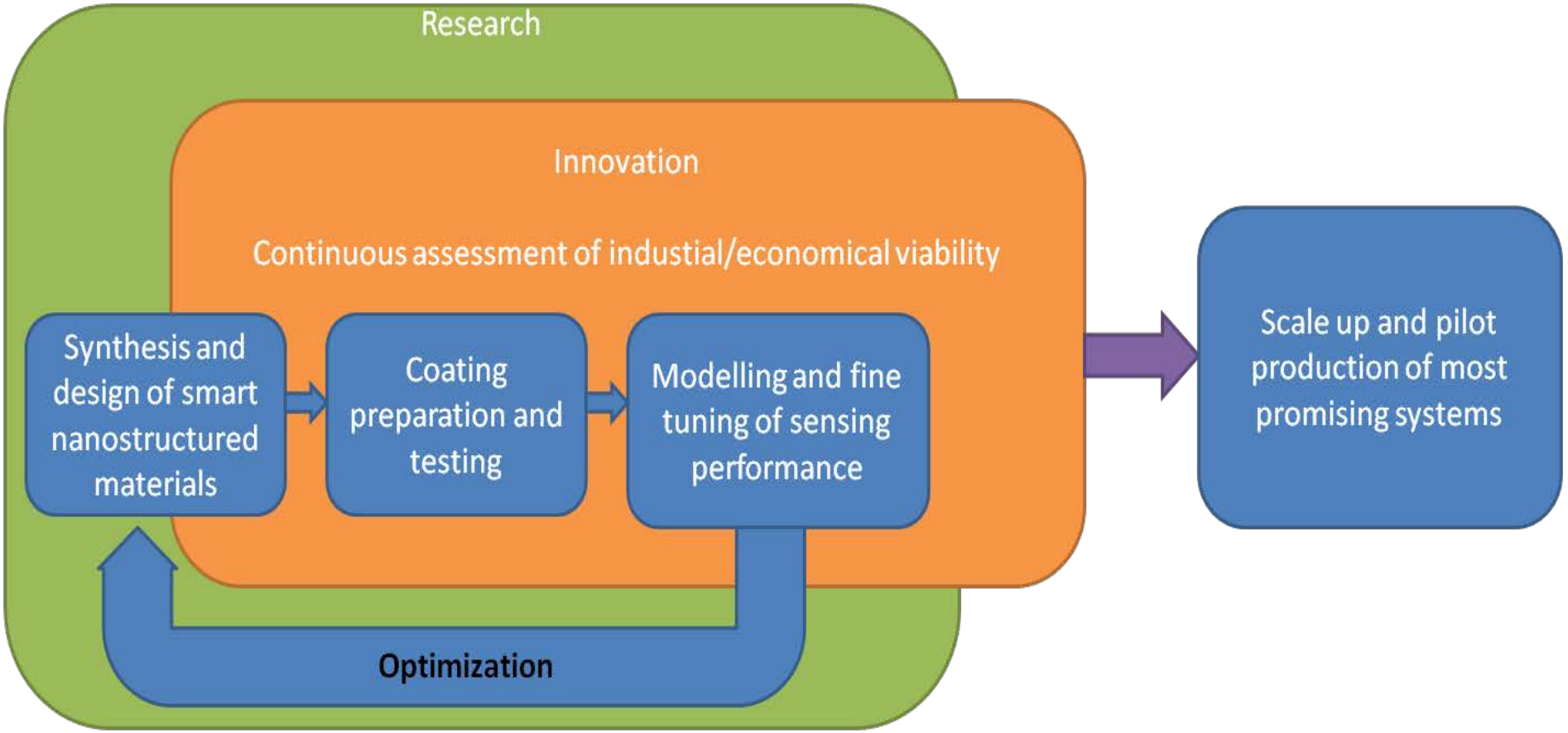
Partners



Map highlighting the complementary between the partners, planned work and tasks

Description of Project

Workpackages



Science Behind

Sensing corrosion: why?

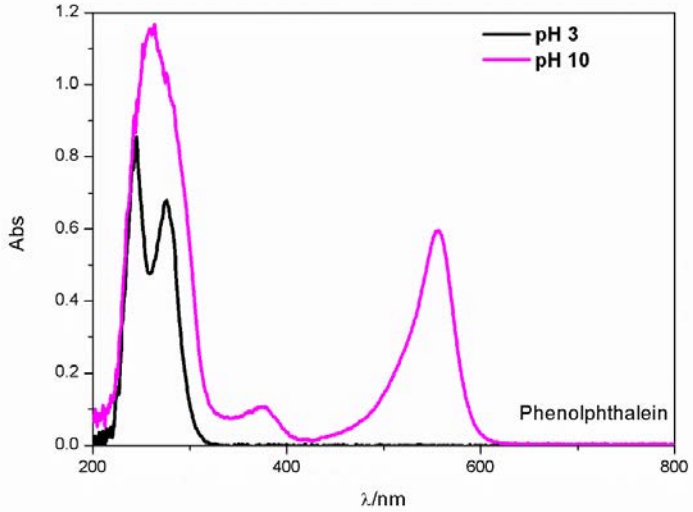
- Sensing *vs*. Protection
- Early detection = lower maintenance/repairing costs
- Continuous monitoring (infrastructures with long-term service life)
- Mechanistic understanding of corrosion processes

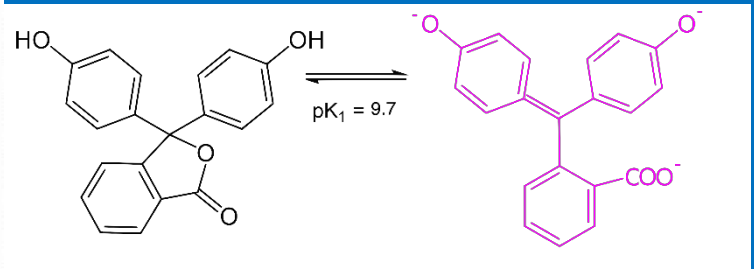
pH indicator molecules

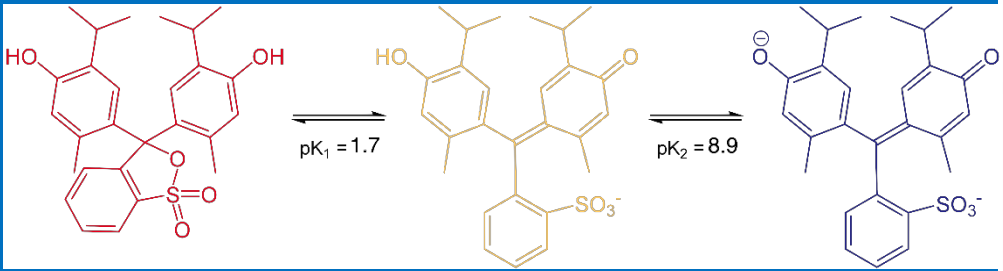
- Signal accessible to human eye: color!
- Simple detection, no need for extra equipment
- Applied in temporary coatings
- Can be used for studying corrosion mechanisms

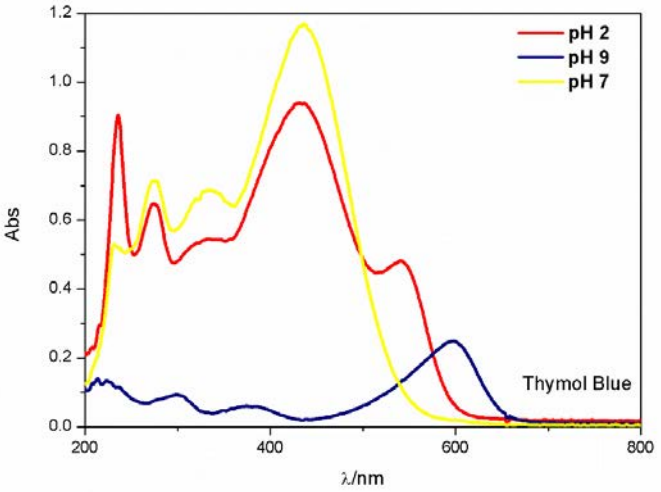
...

pH Indicators





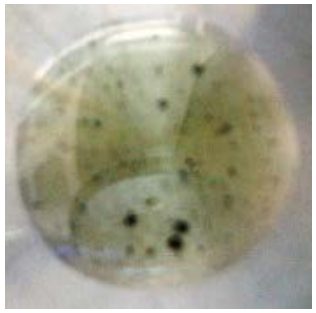




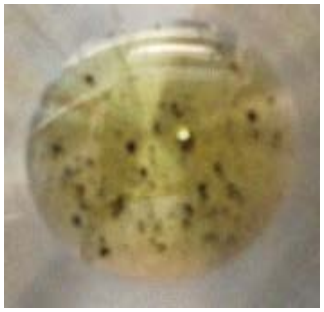
pH Indicators

Challenges

- correlation between color and degree of degradation (quantitative information)
- modification of the rheological properties of coating formulations
- early revelation



Bromothymol Blue

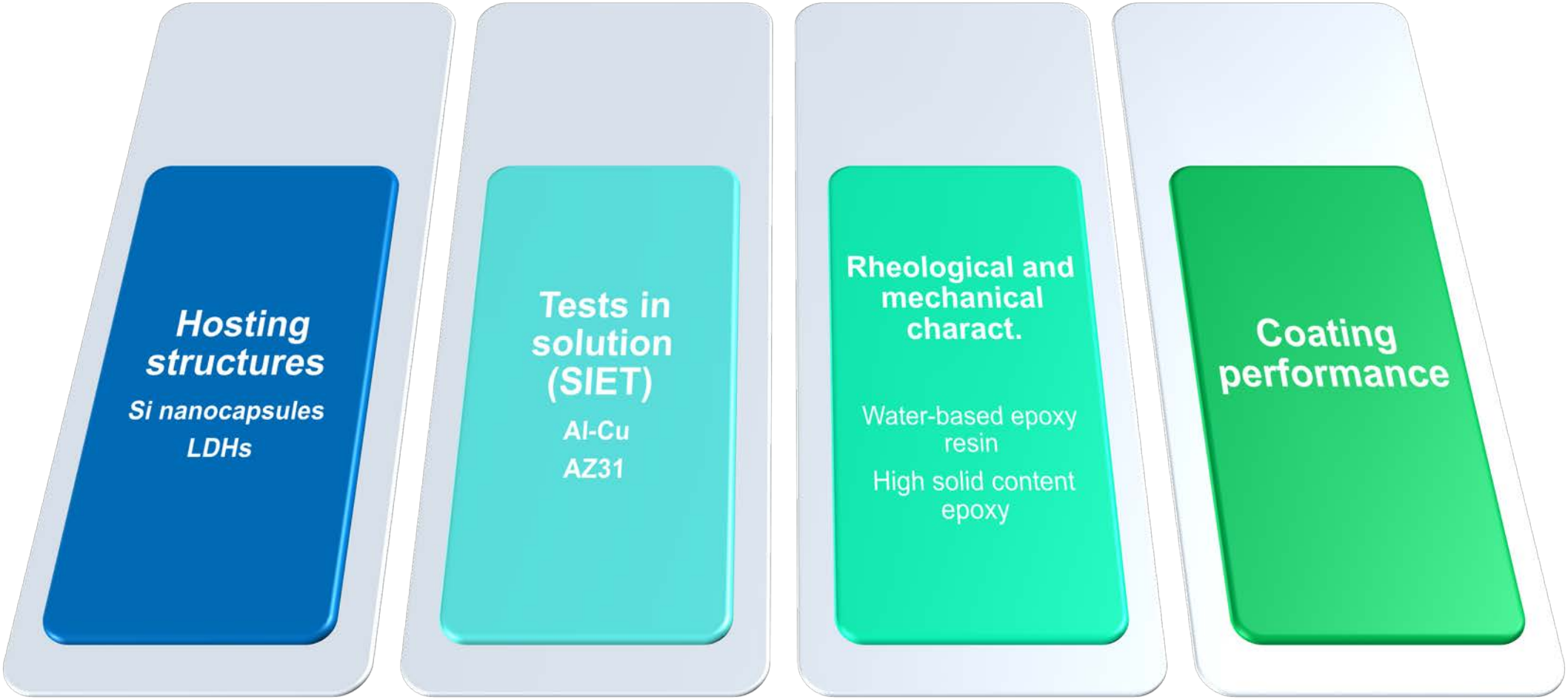


Thymol Blue

Immobilization

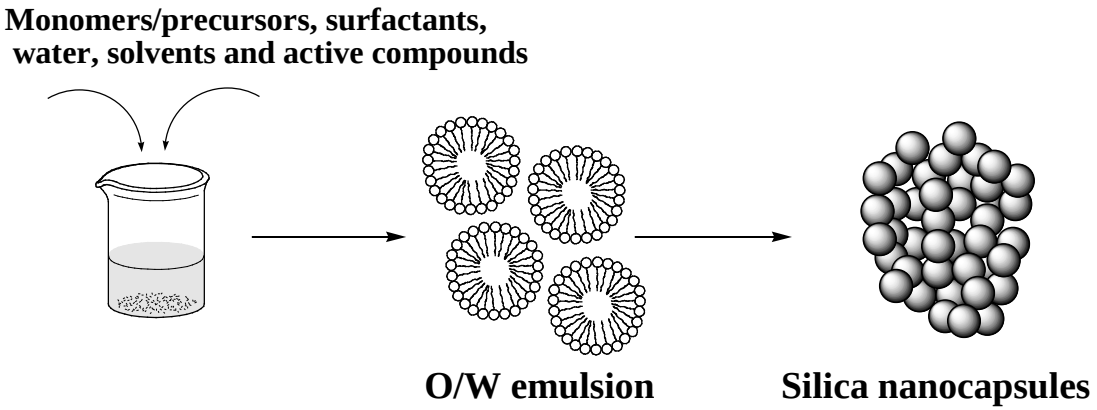
- limit interaction between species and coating formulations
- limit photodegradation (increase stability)
- release dyes when conditions suitable with corrosion are observed (pH, presence of chlorides)

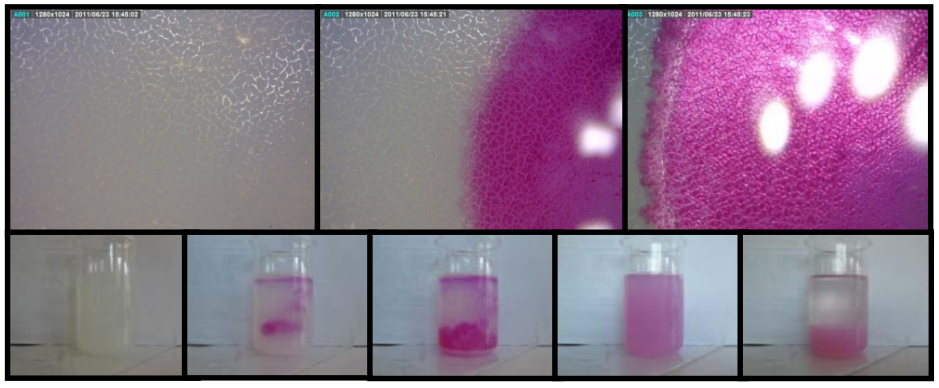
pH Indicators



pH Indicators – Hosting Structures

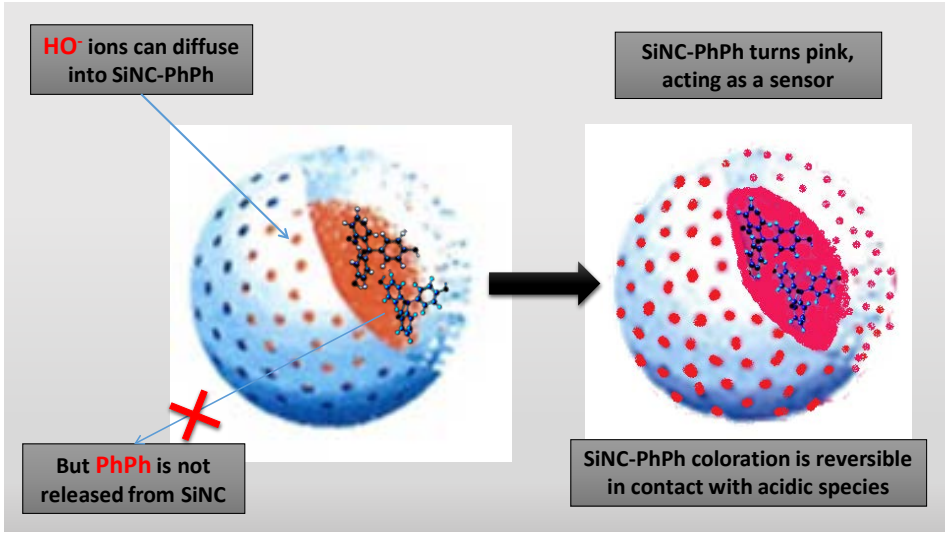
Case 1 – Silica Nanocapsules





Addition of NaOH solution

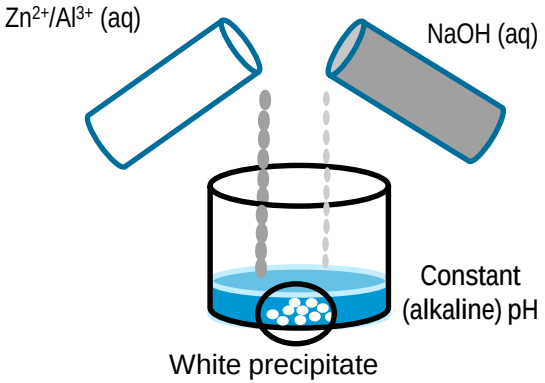
Nanocapsules change color solution remains colorless



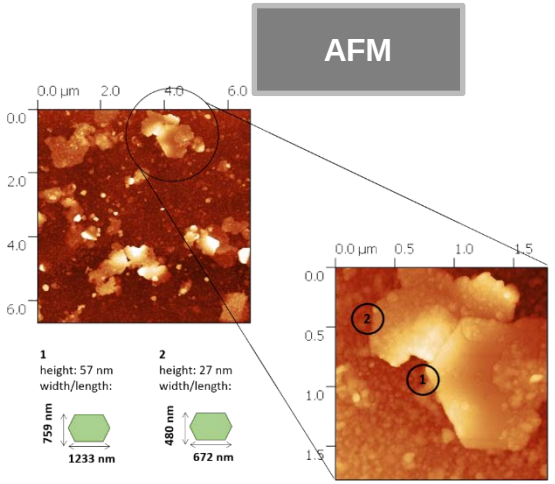
F. Maia *et al.*, Nanotechnology, 2013, 24, 415502-(9pp).

pH Indicators – Hosting Structures

Case 2 – Layered Double Hydroxides



AFM

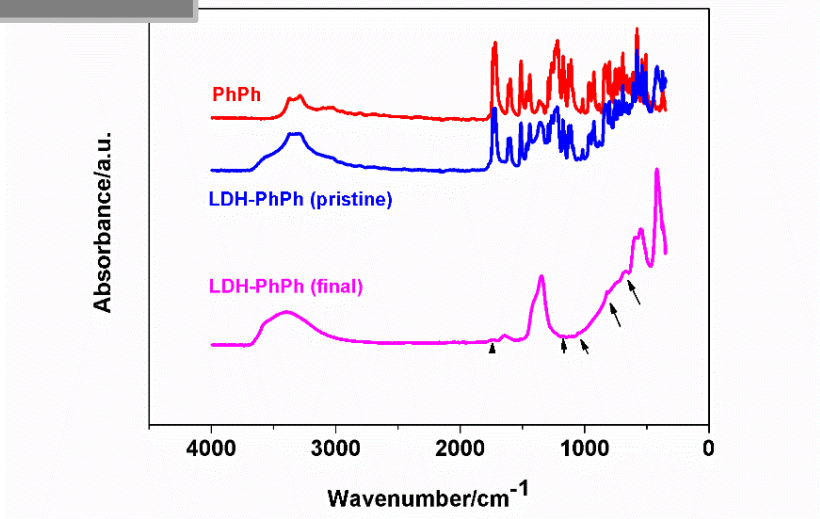


Zn(2)Al LDH-NO_3 [1]

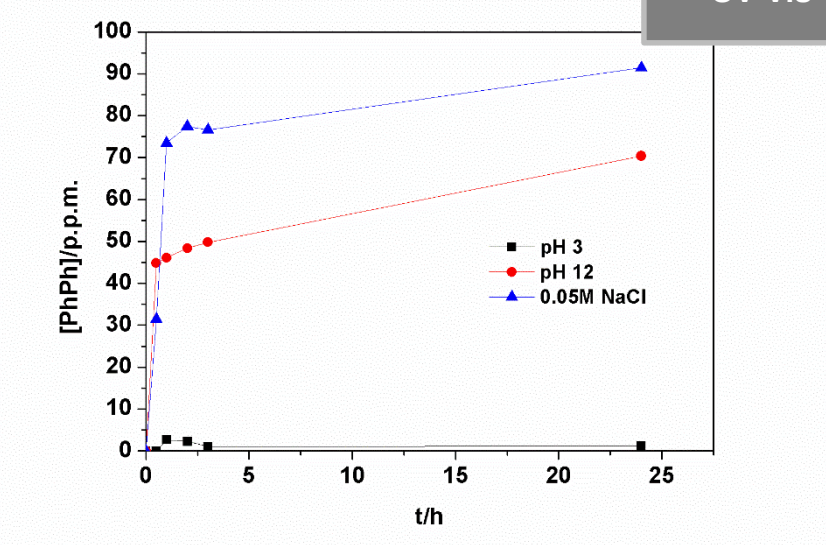
[1] T. Galvão *et al.*, J. Colloid Interface Sci. 2016, 468, 86–94.

FTIR

Phenolphthalein = PhPh



UV-Vis



pH Indicators – Tests in Solutions

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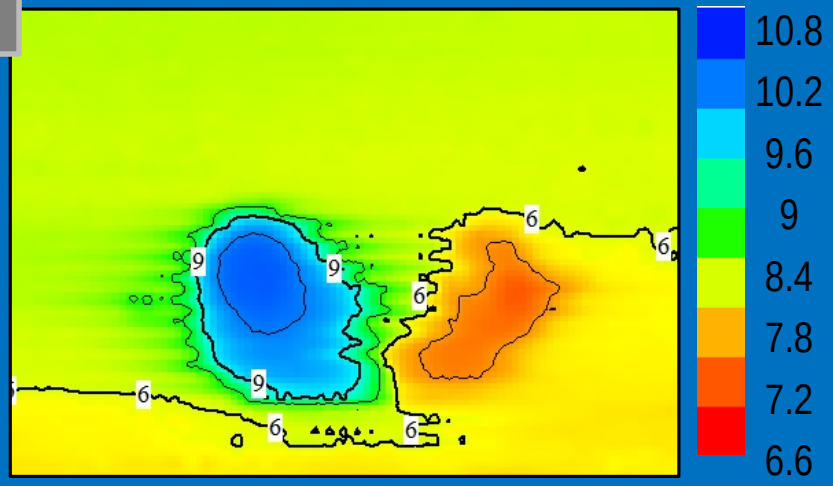
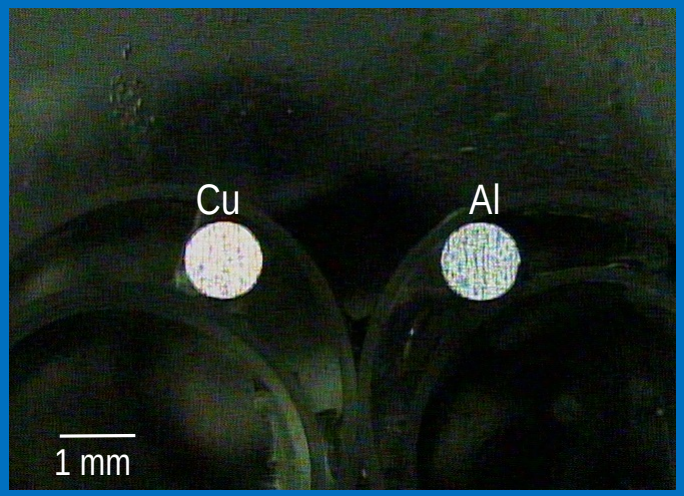
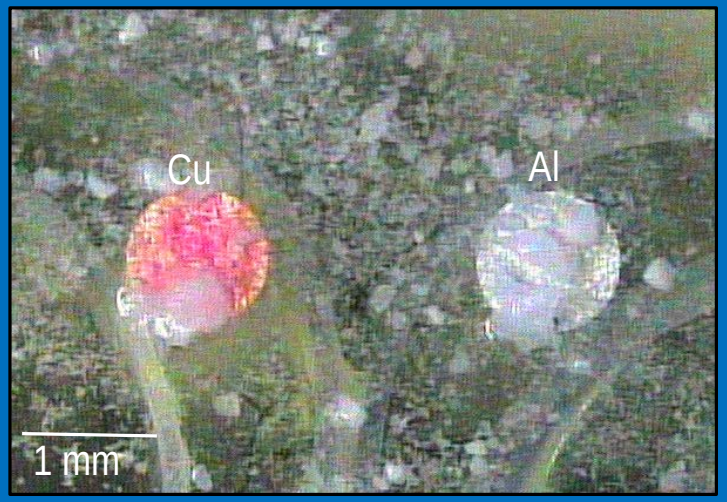
Al-Cu (LDH-PhPh)

SIET







pH Indicators – Tests in Solutions

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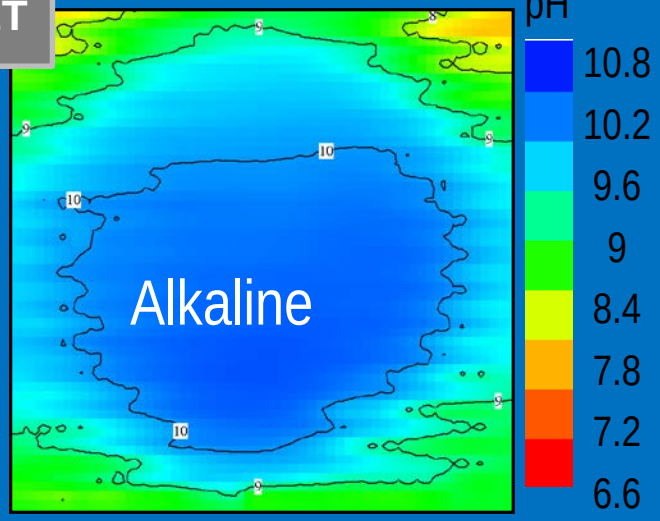
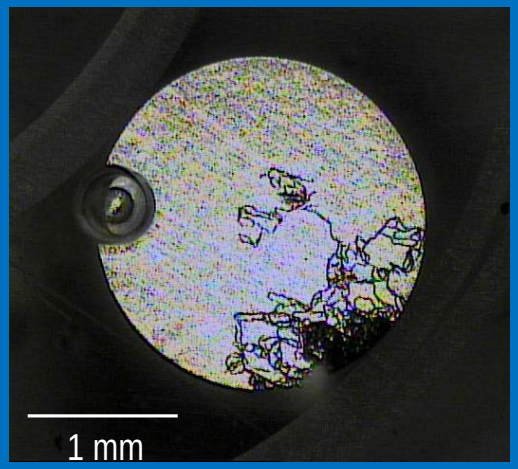
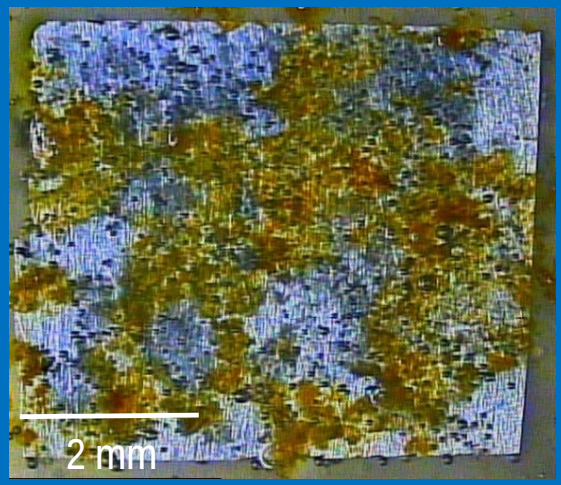
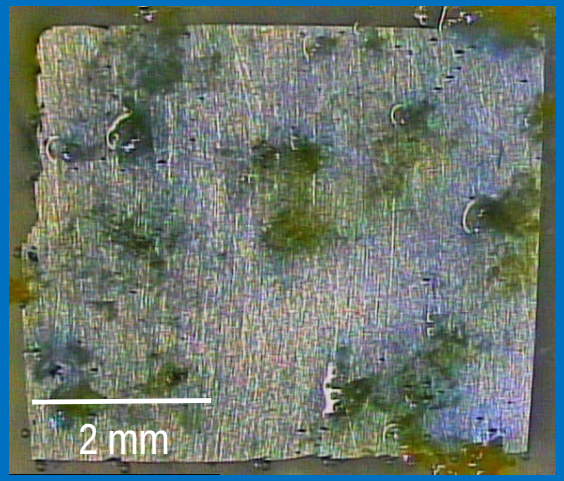
AZ31 (Chitosan-TB)

SIET









pH Indicators – Mechanics

Coating formulations:

- Water-based epoxy (CHS-EPOXY 200 V 55) - water dispersion of an epoxy resin; used for high performance floor coating of concrete, wood, metal and other stable substrates.
- High solid content epoxy (CHS-EPOXY 573) - low molecular weight liquid epoxy resin based on bisphenol A and bisphenol F; used for casting applications and production of insulating materials.

Hosting structures:

- LDH (20 wt% water slurry) – LDH particles without sensing molecules.

pH Indicators – Mechanics

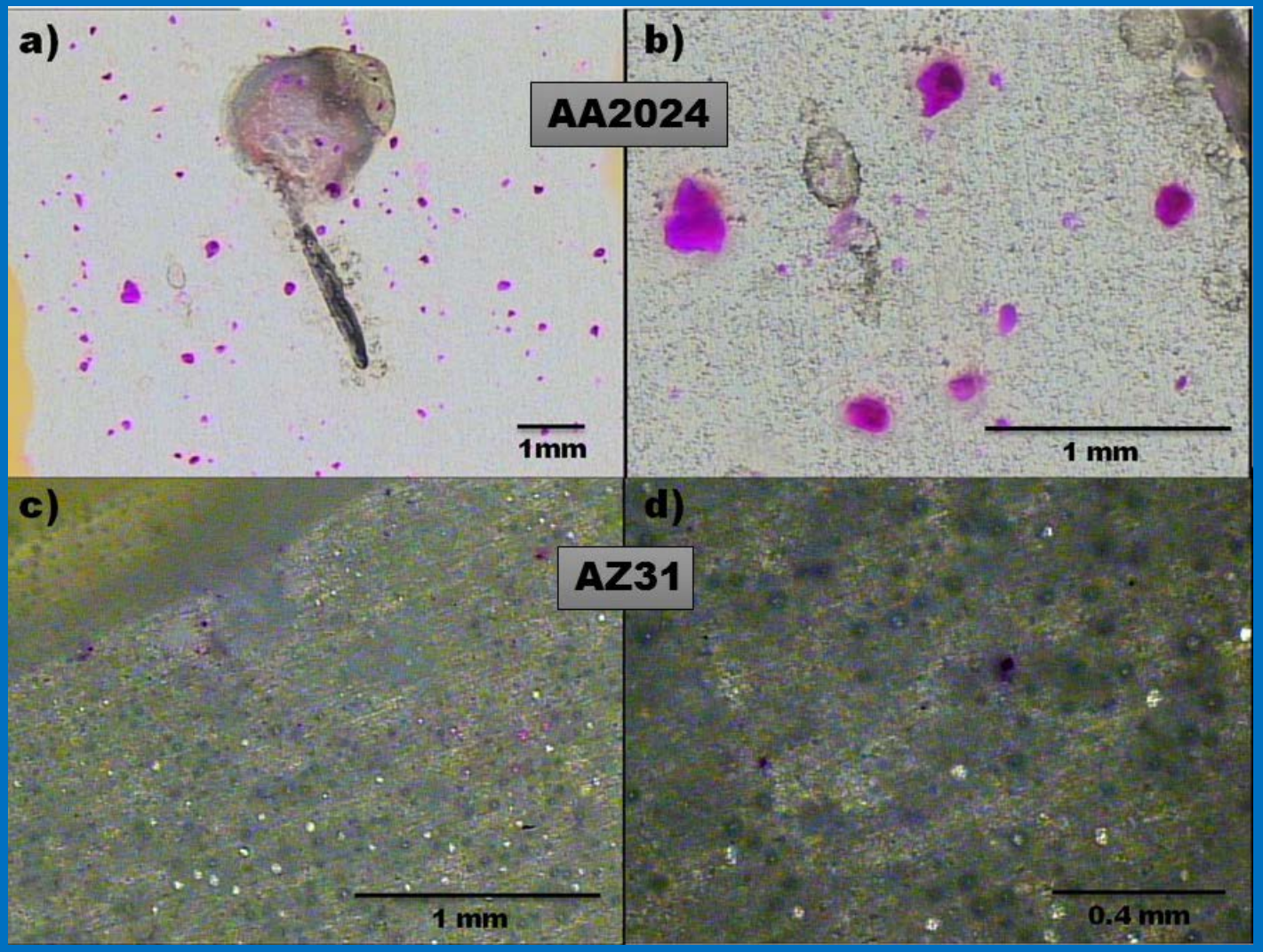
Properties of coating films

	Water based epoxy	**1 % LDH**	**High solid content epoxy**	**1 % LDH**
Pendulum hardness	Reference	+13 %	Reference	–1 %
	Reference	+3 %	Reference	+2 %
Impact resistance	Reference	≈	Reference	≈
Bend test	Reference	≈	Reference	≈
T_g / ºC	68	---	99.8	102.4
Tensile strength (free films)	Reference	–21 %[a]	Reference	≈

[a] this value needs other tests and further confirmation

pH Indicators – Coating performance

(SiNC_PhPh)



- Aqueous Epoxy resin
- 20 µm thickness
- 3 days 0.5M NaCl@RT

F. Maia *et al.*, Nanotechnology, 2013, 24, 415502-(9pp).

Conclusions

- Immobilization of pH indicators in hosting structures can limit/control the release of dyes.
- Color changes were correlated with corrosion activity in Al-Cu and Mg alloy AZ31.
- Promising results in terms of corrosion detection for coatings with inorganic and polymeric systems for AA2024 and AZ31.

Acknowledgements

SMAR C AT
http://smarcoatrise.wix.com/smarcoat

European Commission

University of Aveiro
Portugal

Helmholtz-Zentrum Geesthacht
Germany

SMT SMALLMATEK
Smallmatek
Portugal

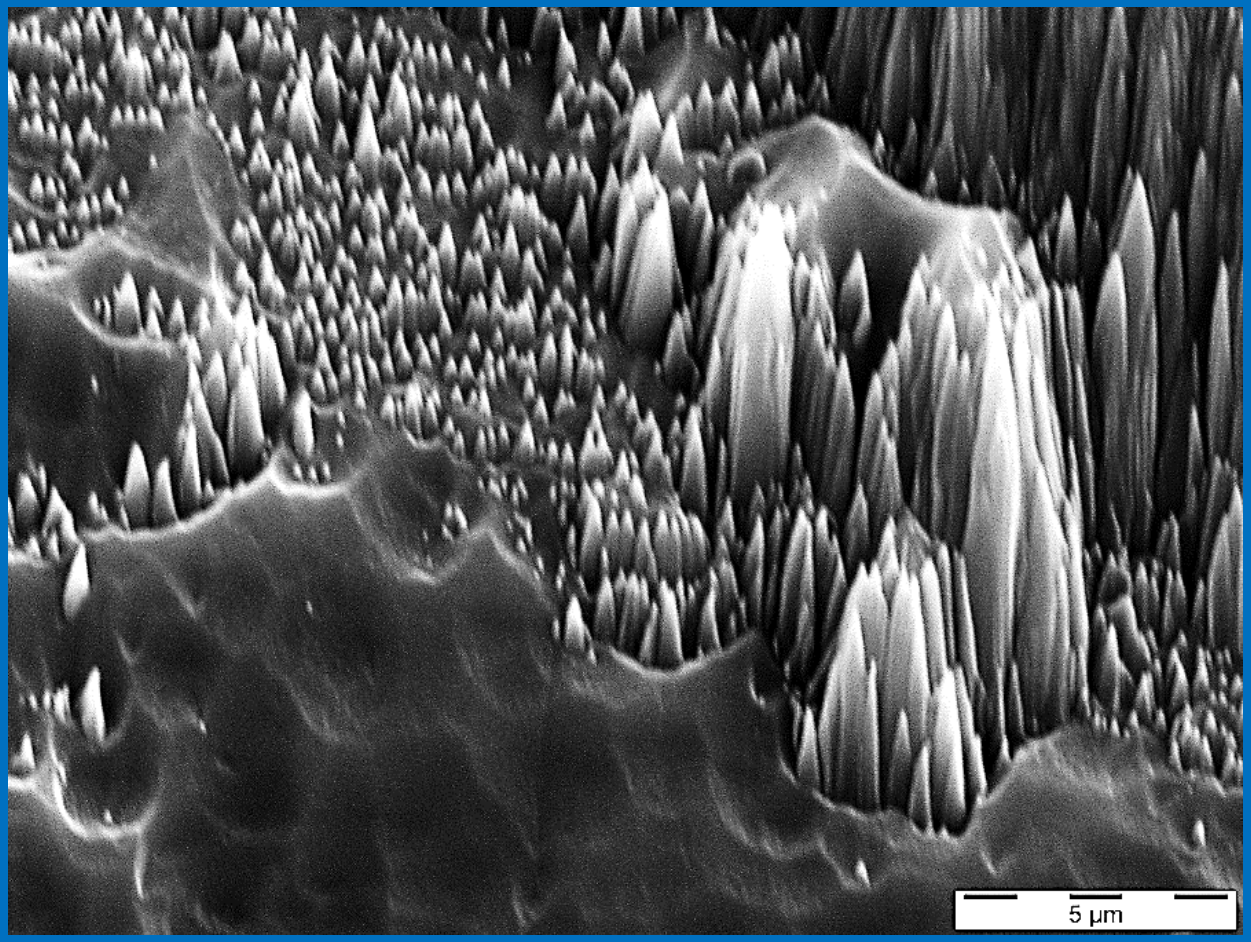
University of Latvia
Latvia

Belarusian State University
Belarus

Synpo
Czech Republic

This project has received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Skłodowska-Curie grant agreement No 645662.

Thank you for your Attention ☺



SEM micrograph of a Mg alloy after Ar-etching

Only understanding the past offers perspectives for the future

(Konfuzius)