IK4 CIDETEC
Research Alliance

Corrosion and fouling in offshore

Corrosion and fouling in offshore

Overview

Offshore components and devices have serious technical and economic problems as a result of aggressive phenomena of fouling and corrosion.

The traditional solutions to avoid:

- **Biofouling phenomenon**: Biocides, usually highly polluting substances, most of them included in paints and polymeric agents.
- **Corrosion**: Expensive materials, substrates (stainless steels, Ni alloys, Titanium, etc.) and oversized designs for the purpose of increasing the whole life cycle of the component.

Faced with this scenario, there is a need for many industries to **develop environmentally** sustainable **solutions** to protect offshore structures. A technical solution based on **advanced coatings** with corrosion resistance and anti-fouling properties could improve the yield and reduce costs.

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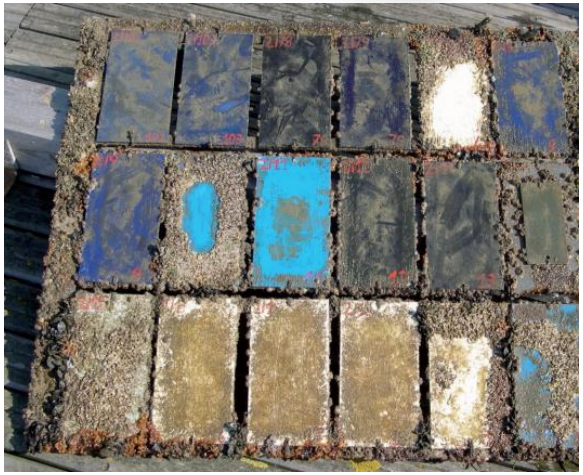
Overview

For certain applications, **paints** may have several disadvantages:

- Low resistance to scratching and wear
- Chemical stability problems at certain temperatures
- Low adherence (mechanical) to the substrate
- Usually they have to be replaced regularly to maintain the main properties.



Ceramic coatings could be a good environmentally friendly alternative in certain offshore components with high corrosion and biofouling resistance.

Corrosion and fouling in offshore

Overview

PROPERTIES:

1. FUNCTIONAL:

1.1. Physical properties:
- Temperature resistance
- Resistance to thermal shock

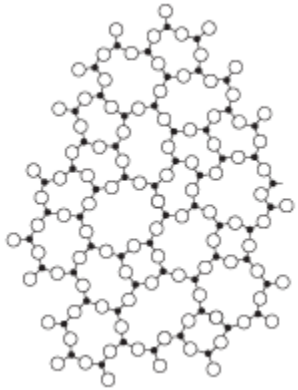
1.2. Chemical properties:
- Resistance to chemical agents
- Resistance to atmospheric agents
- Impermeability

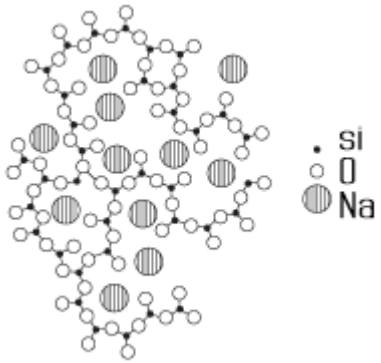
1.3. Mechanical properties:
- Hardness
- Scratch resistance
- Abrasión resistance
- Impact resistance

1.4. Hygienic properties:
- Inhibit bacterial growth
- Cleanability

2. AESTHETICS:

2.1. Finishings
2.2. Varied colors
2.3. Visual effects
2.4. Stability





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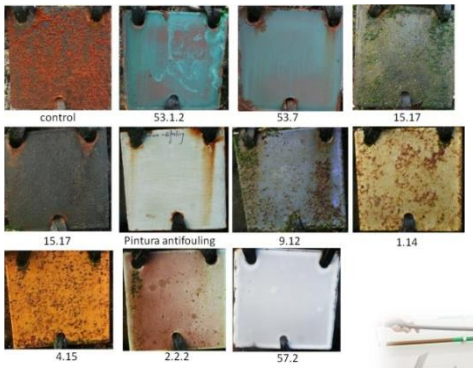
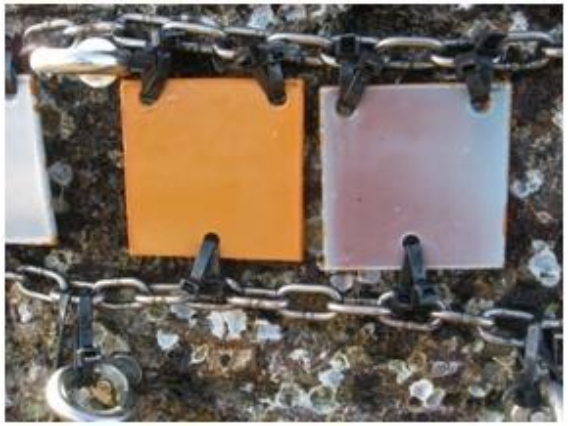
Ceramic approach with enamels coatings

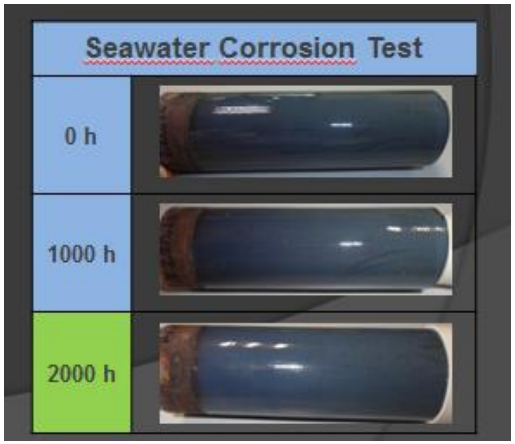
Coatings with anticorrosive / anticlogging properties for Offshore systems





UNE-EN ISO 9227:2012

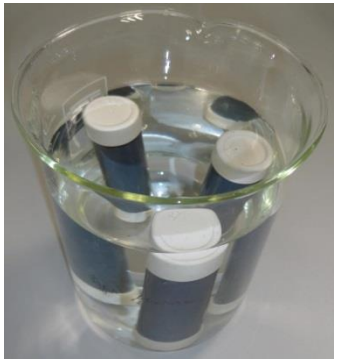
ASTM D5479-94 (2013), ASTM D6990-05 (2011)



Up-scaling and field test

Development of vitreous coatings on carbon steel that has to overcome more than 20 years in offshore conditions without corrosive processes and antifouling

Ceramic approach with enamels coatings



- **Seawater Corrosion Resistance (Offshore):**
  - **Conditions**:
    - Solution: 3,5% NaCl at 22 ^{0}C
    - Visual inspection after test

HIGH CORROSION RESISTANCE FOR OFFSHORE APPLICATIONS

Seawater Corrosion Test	
0 h	
1000 h	
2000 h	

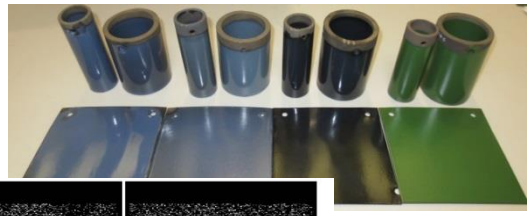
Corrosion and fouling in offshore

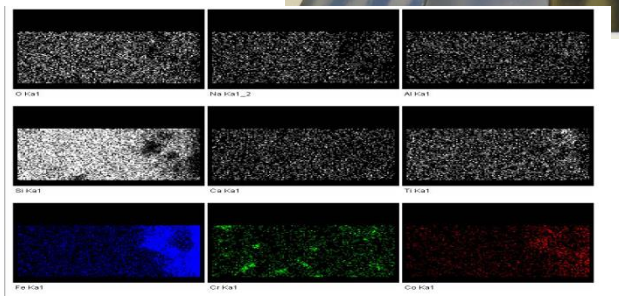
Ceramic approach with enamels coatings

The application of **ceramic coatings based on advanced enamels** with antifouling properties in offshore structures is completely new.

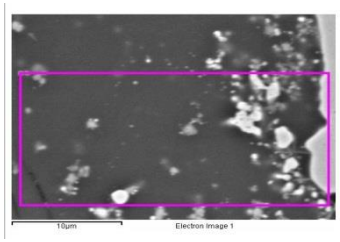
IK4-CIDETEC, is actually working on different projects based on the development of **ceramic coatings** with high corrosion resistance and antifouling properties under seawater immersion conditions:

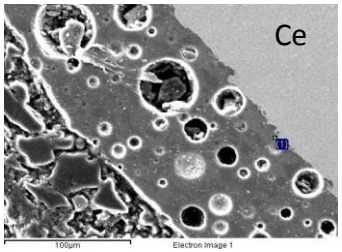
- Chemically bonded to the substrate
- Incorporating active ceramic particles against fouling as silver, copper, vanadium, cerium, zinc, titanium, etc.

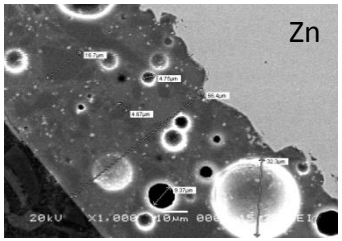


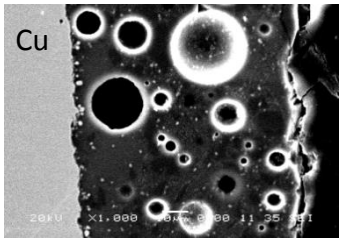


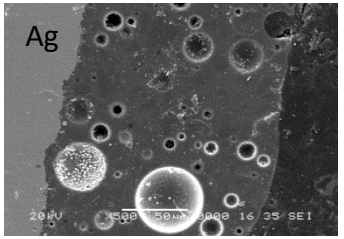
Mapping interface









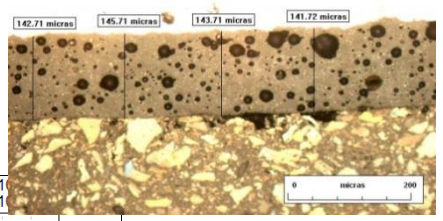


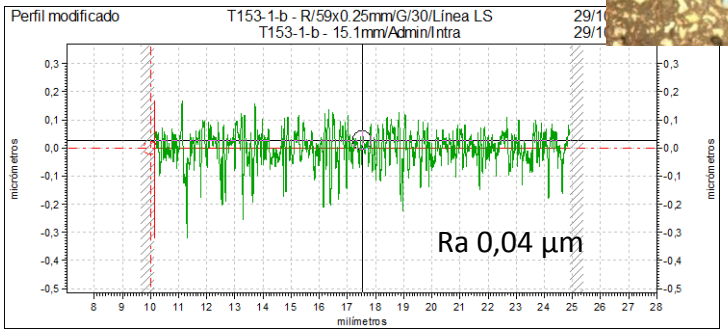
SEM

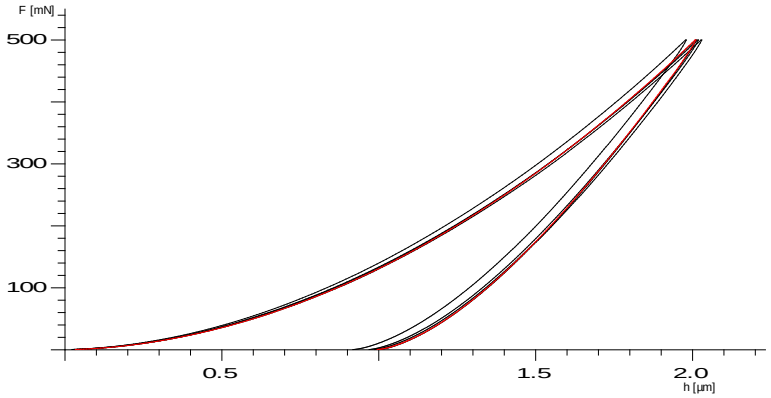
Ceramic approach with enamels coatings

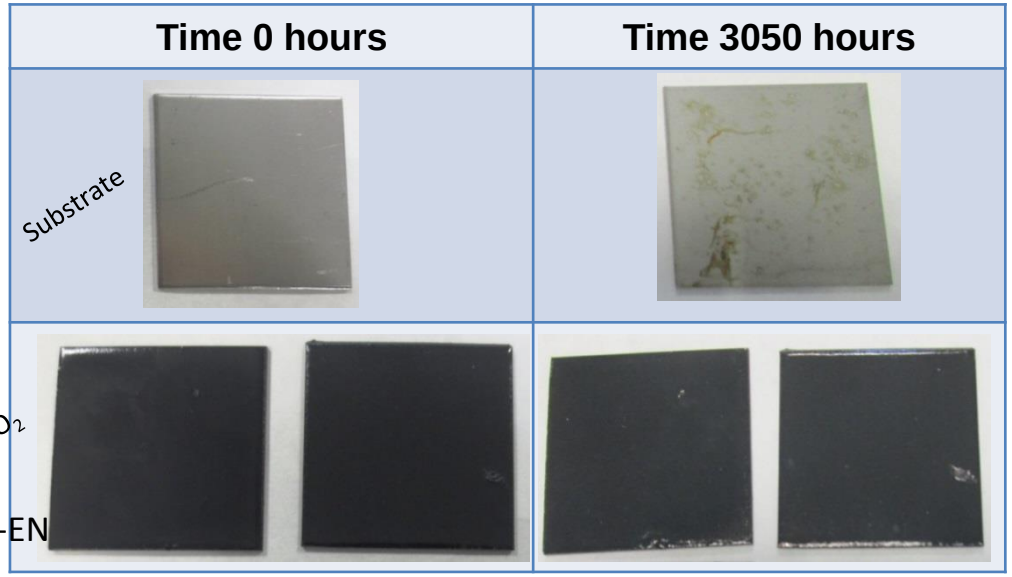
Properties

- Thickness: 100-150 mm.
- Corrosion resistance: good.
- Coating adherence (UNE-EN-10209): good.
- Roughness (ISO 25178): Ra = 0,03 - 0,06.
- Hardness (ASTM C 1327-03): 750-800 Hv.









Accelerated corrosion in Salt Spray test UNE-EN ISO 9227:2012

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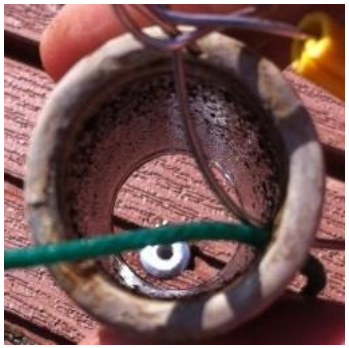
Proof of concept

Some ceramic formulations developed in IK4-CIDETEC are currently under evaluation in a test bench to analyse the effect of active ceramic nanoparticles in the antifouling properties, showing a good behaviour at early stages.

- Check corrosion resistance.
- Check biofouling.
- Check ease of cleaning.

Seawater immersion in Plentzia harbour (Cantabrian sea)

Initial development



nanoZnO

nanoCu

V_2O_5

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Outcome

- Enamel coatings with chemical adherence to the metal substrate (better in carbon steel than in stainless steel)
- Enamel coatings with high corrosion resistance in salt medium
- Nanoparticles integration in ceramic structure trying to get the functionality at the surface with no lose of corrosion properties
- Smooth surface (low roughness) to try to avoid fouling adhesion
- Enamel coatings developed over sheet an tube coupons (inside the tube the proliferation of algae and molluscs is higher, calmest zone)
- Direct testing in test bench

Future Steps

- Monitoring the results.
- Adjust the formulations.
- Analyse the biocidal compounds distribution (specially in the interface substrate-ceramic)
- New biocidal compounds compatible with enamel vitreous structure.
- Effect of particle size (nanoparticles).
- Compare the results.

ESKERRIK ASKO
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THANK YOU VERY MUCH
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