Universidad de Cantabria

UNIVERSIDAD DE CANTABRIA
Biofouling Research Group

RECUBRIMIENTOS CERÁMICOS BIOACTIVOS PARA LA OPTIMIZACIÓN ENERGÉTICA EN LA INDUSTRIA NAVAL PESQUERA

BIOACTIVE CERAMIC COATINGS FOR ENERGY OPTIMIZATION IN THE FISHING NAVAL INDUSTRY

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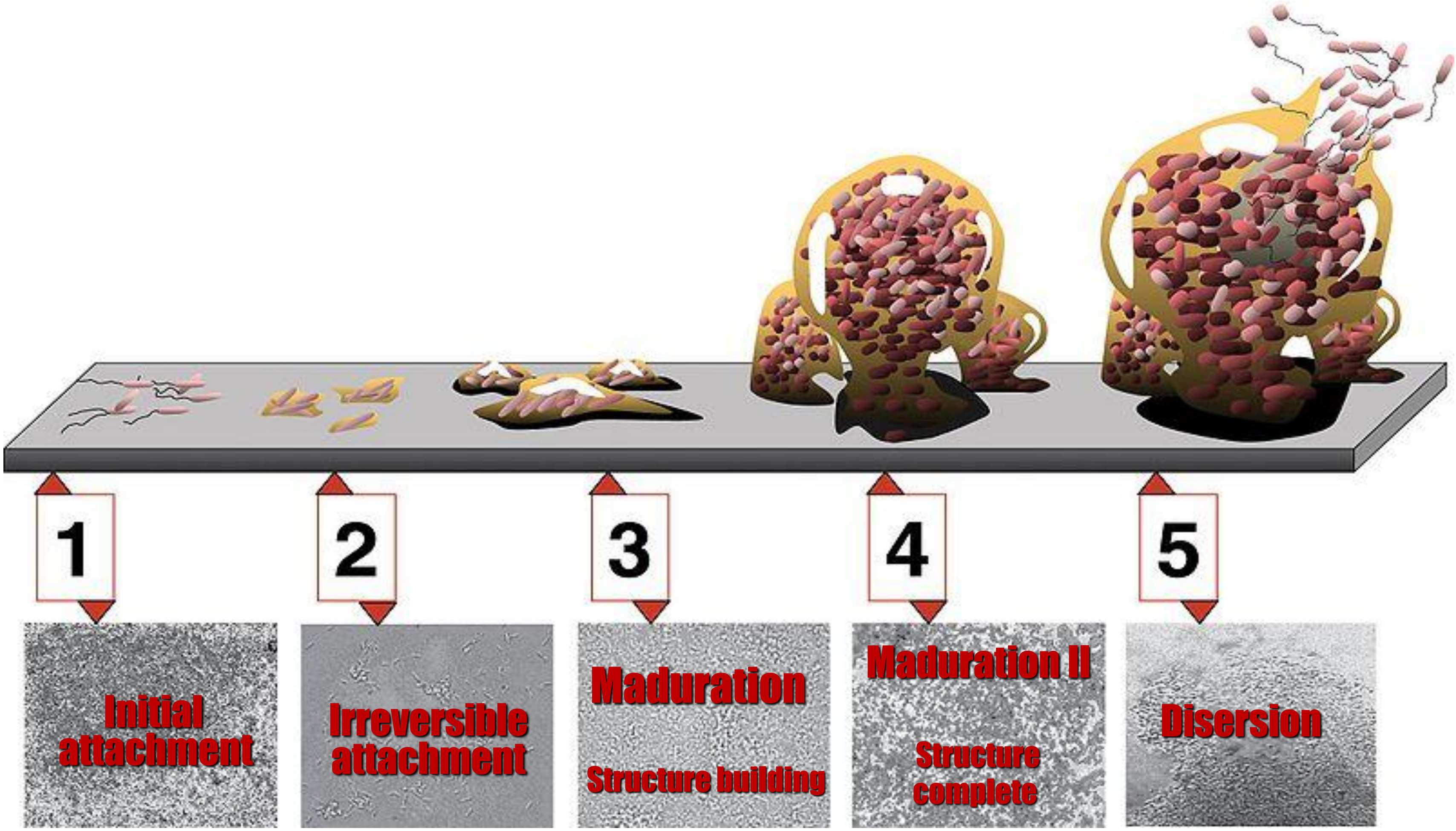
What is the problem in ship hulls?

Corrosion!!

- High cost of maintenance.
- Short lifetime. Organic paint coatings lifetimes (<5 years).
- Undesirable accumulation of marine life (Biofouling).

How is Biofilm Created?



Main factors in biofouling development

- **Related to the materials**

  Composition

  Roughness

  Working Conditions

- **Related to water**

  Temperature

  pH

  Oxygen

  Water flow (velocity)

  Non-Organic Components

  Biological Activity

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Ways to Fight Against Biofouling

- **Physical Methods.**
  - Elctromagnetic fields.
  - Ultrasounds.
  - Thermal treatments, etc.
- **Chemical methods.**
  - Biocides.
  - **Antifouling coatings.**
- **Biological methods.** Encymes as such:
  - Oxidorreductases.
  - Transferases.
  - Hydrolases.
  - Lyasas.
  - Isomerases.
  - Ligases.

Main Goal of the Investigation

- To minimize the biofilm adhesion on the surface.
- To predict a ship's frictional and total resistance of a fresh hull protected with ceramic coatings after a year of exposure in a natural environment and compare these results with those obtained for the same hull coated with conventional paint.

This study was conducted using a RANS model from an open-source CFD toolkit, OpenFOAM.

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Materials and Methods

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Area of Study

❖ **Bay of Santander (Spain)**

Localization: (Cantabrian Sea)
43° 27.7′N and 3° 47,5′W

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Marine Laboratory

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Laboratory

Preparation of samples

- The conforming of the three different ceramic materials will be carried out over carbon steel (A569/A569M6, 3 mm thick by 200 mm x 300 mm) which will be visually examined and tested once a month according to ASTM D790.
- Before coating application, the sample surface was blast cleaned in order to get a final surface roughness of Sa2.5 or Sa3 (ISO 8503) and cleanliness (ISO 8501).
- Commercial silicone-based coatings were applied over carbon steel (A569/A569M6, 3 mm thick by 200 mm x 300 mm) which was visually examined and tested according to ASTM D790.

Base Material A-569										
Coating	Elements (%)									
	O	Na	Al	Si	K	Ti	Co	Mg	P	Ca
Blue glaze BK	57,81	8,09	0,92	23,79	3,78	3,29	2,34	-	-	-
Dark grey paint Coating	Intersleek 970									

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Biofouling assessment in Marine Laboratory

- Experimental plates were submerged during 365 days in the shallow marine environments, at a depth of 0.5 m (06 February 2024 - 06 February 2025), Monthly - visual inspection following the ASTM D 3623-78a.
- Temperature of seawater was measured daily during the experiment period. Daily- mS m^{-1}, pH and O_2.
- Measurement of barnacle adhesion strength in shear as follow ASTM D5618-94.
- Analysis quantitative and qualitative of biofouling on sampled surfaces.
- The evaluating biofouling resistance and physical performance of marine coating system in related ASTM D6990-05.

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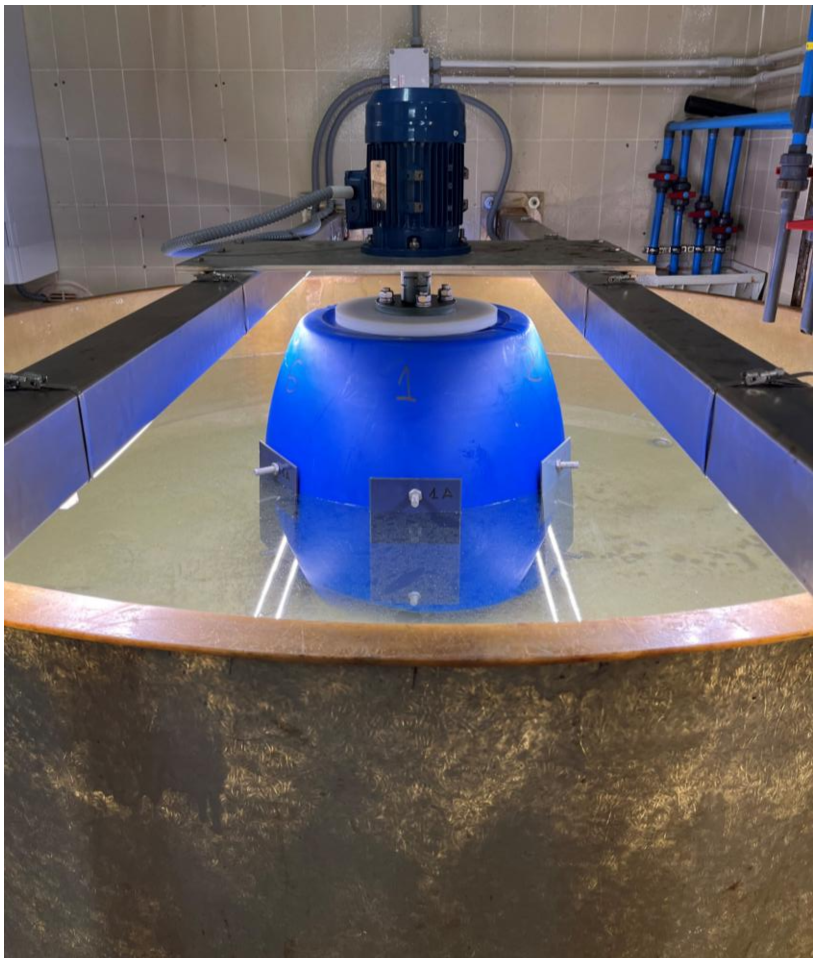
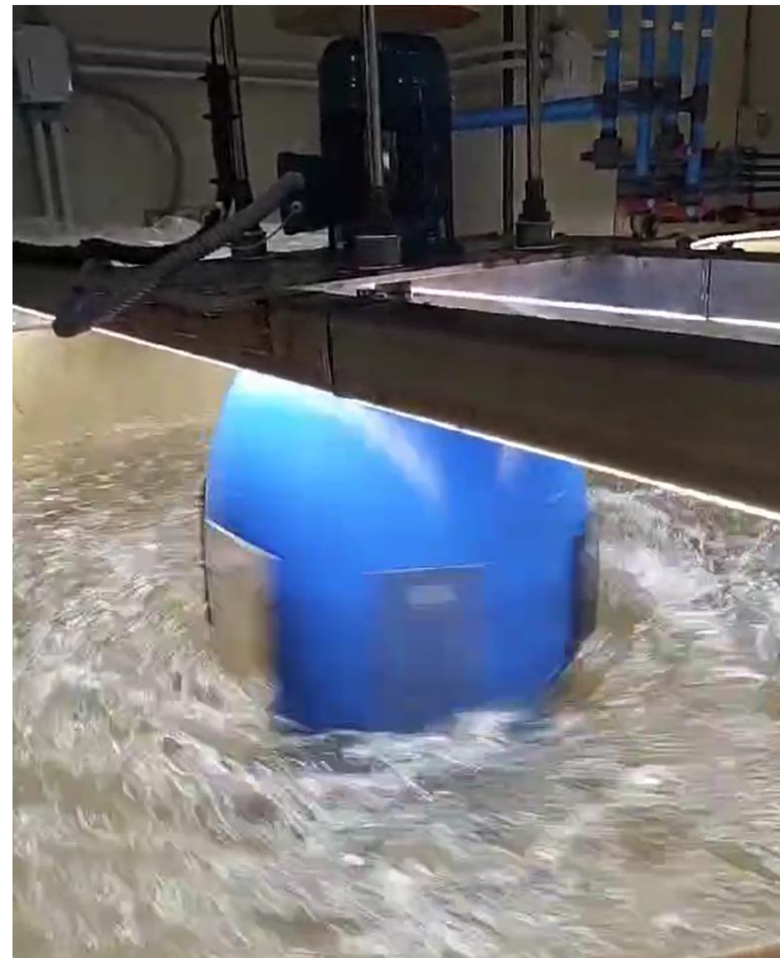
Biofouling assessment in Laboratory



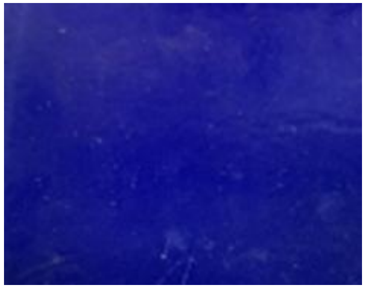


Results

Antifouling performance of Ceramic Coating

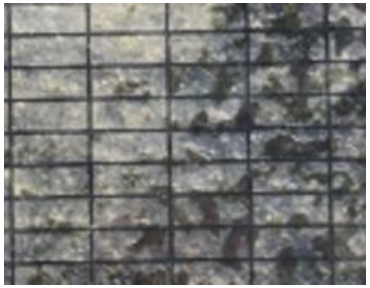
Fouling rating %	Physical Condition (Defects) %	% Cover			
		filamentous bryozoans	barnacles	algae	Biofilm
85	22	13	27	40	20

0 day exposed

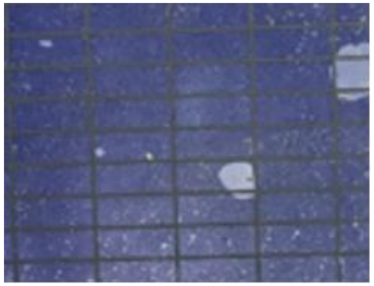


Roughness: 0.721 µm
Thickness: 217 µm

365 day exposed



Before washing



After washing

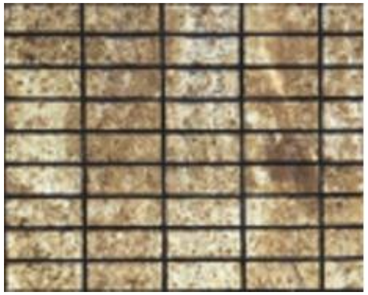
Antifouling performance of Paint

Fouling rating %	Physical Condition (Defects) %	% Cover			
		filamentous bryozoans	barnacles	algae	Biofilm
95	74	20	3	27	50

0 day exposed

Roughness: 72 µm
Thickness: 300 µm

365 day exposed



Before washing

After washing

Experimental-panels roughness

Material	Roughness in marine laboratory (µm)		
	0-months exposure	1-months exposure	12-months exposure
Ceramic coating	0,721	10,2	1457,14
Paint	72	76	273,63

	Roughness in laboratory (µm)			
	0-months exposure	1-months exposure		12-months exposure
		Static conditions	Dynamic conditions	Dynamic conditions
Ceramic coating	0,721	8,3	2,1	103,4
Paint	72	73	73	203,5

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Physical-chemical properties of seawater

- Temperature 12-22 ºC
- Conductivity between 39-60 mS m^{-1}
- pH 8-8,2
- Oxygen dissolved 8,15-8,65 mg/L

Conclusiones

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Lessons Learned

Biofouling is formed by a diverse group of microorganisms in coatings with different compositions.

The roughness of the surface of coatings directly affects biofilm development on coating surface.

Ceramic coatings have an excellent antifouling performance even under static conditions for more than 1 year.

The hydrodynamic shear effect exerted on coatings with biofouling causes the near-total removal of biofouling from the surface due to its low roughness.

Ceramic coatings with suitable compositions are recommended to the applications in marine antifouling.

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