# The Impact of Graphene Composite Surfaces on the Development and Architecture of Marine Cyanobacterial Biofilms


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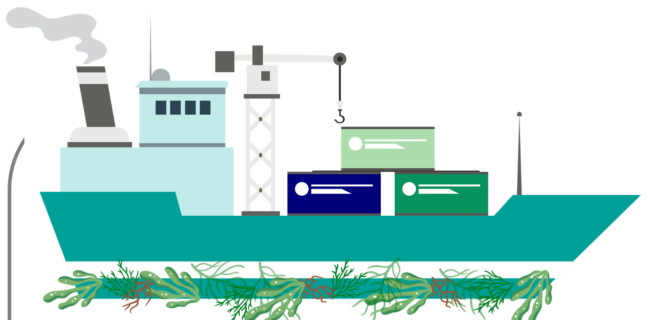


Attachment of **organisms**

Increased **drag force**

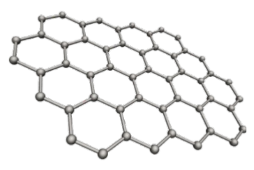
Higher **fuel consumption**

Greater release of **greenhouse gas**

## Introduction

**Biofouling** is a widely recognized concern in the marine sector, leading to **losses of billions of dollars** every year, globally, as a result of increased **transport delays** and **hull maintenance** procedures.

Due to its significant **economic and ecological** implications, the search for effective non-biocide-release marine **antifouling coatings** has been on the rise.



**GRAPHENE NANOPLATELETS (GNP)**
*single-layer sheets of sp²-hybridized carbon atoms*

**GRAPHENE'S POSTULATED ANTIBACTERIAL MECHANISMS OF ACTION**

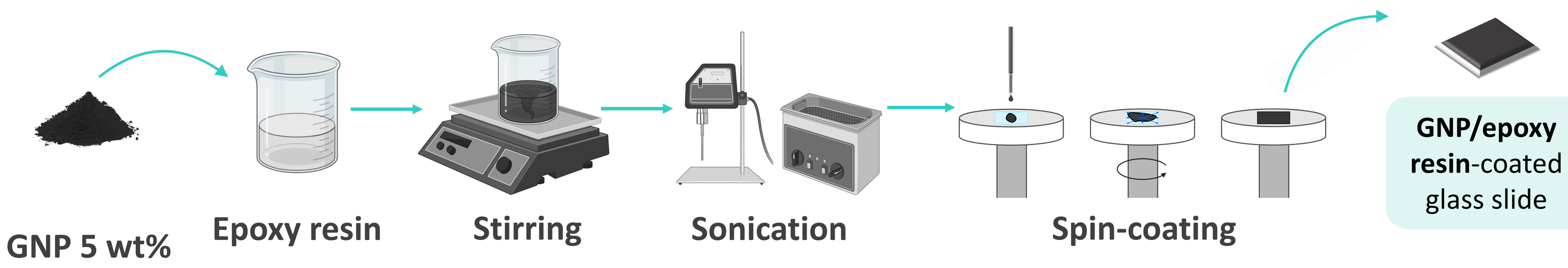
- **Membrane piercing**
- **Cell entrapment**
- **Oxidative stress**

## Objective

To produce and characterize a **GNP/epoxy resin** composite surface and assess its impact on **cyanobacterial biofilm formation** over a **long-term *in vitro* assay** under **hydrodynamic conditions** present in real marine environments.

## Methodology

### 1. SURFACE PREPARATION




### 2. SURFACE CHARACTERIZATION

**Contact Angle Measurements**
*Surface Wettability*

**Optical Profilometry**
*Surface Roughness*

**Scanning Electron Microscopy (SEM)**
*Surface Morphology*

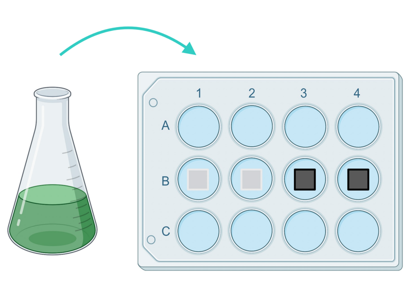
### 3. INOCULUM PREPARATION

***Lusitaniella coriacea* LEGE 07157**

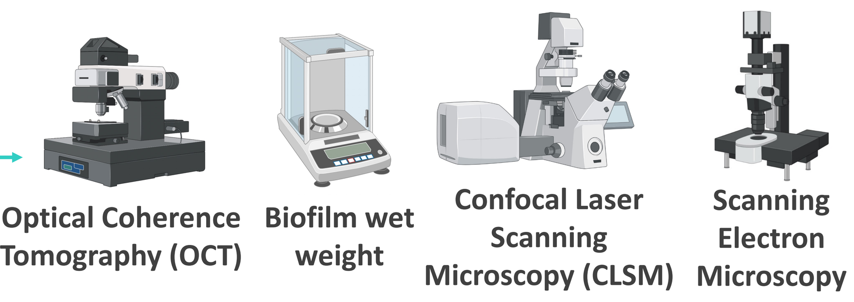
**Z8 medium**

**Chlorophyll *a* concentration adjustment**

### 4. BIOFILM FORMATION AND ANALYSIS



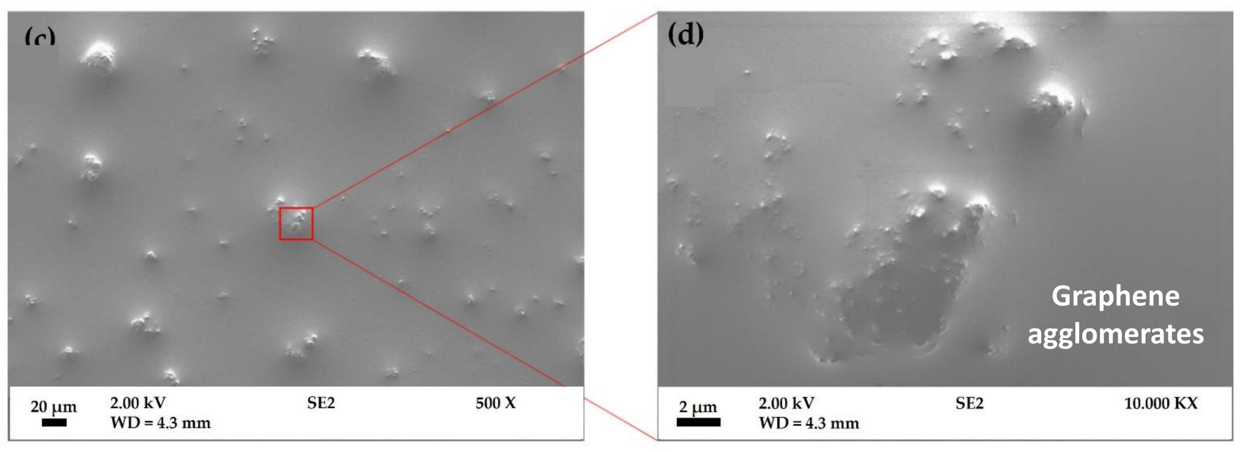

**Incubation**
**7 weeks, 25 ºC, 185 rpm** *(average shear rate = 40 s⁻¹)*



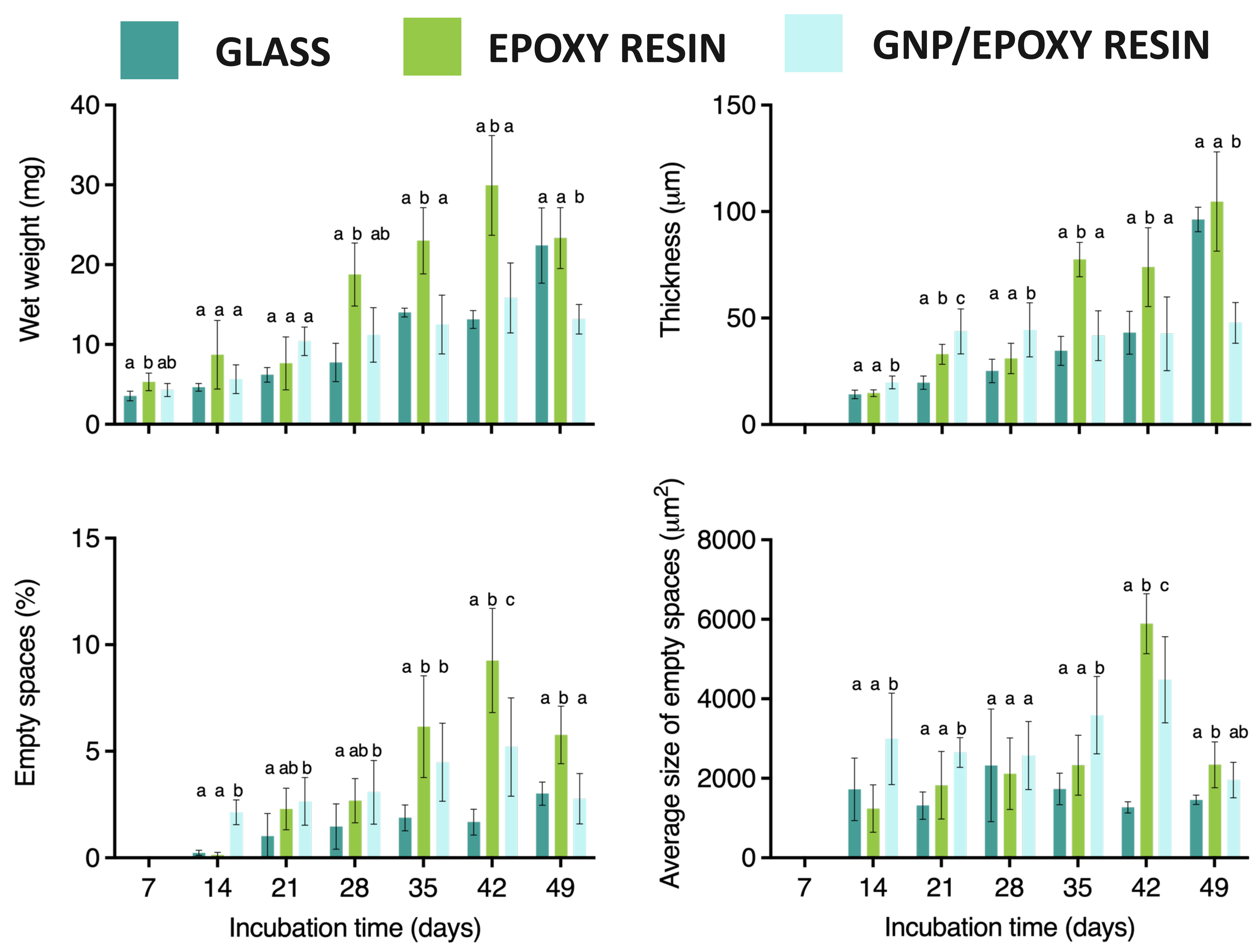

## Results

### SURFACE CHARACTERIZATION

- Bare **epoxy resin** and **GNP/epoxy resin** surfaces are slightly **more hydrophilic** than glass.
- The **GNP/epoxy resin** composite displayed about **10x greater** average surface **roughness** than both glass and bare epoxy resin.
- **SEM images** showed **graphene agglomerates** on the surface of the **GNP/epoxy resin** composite.

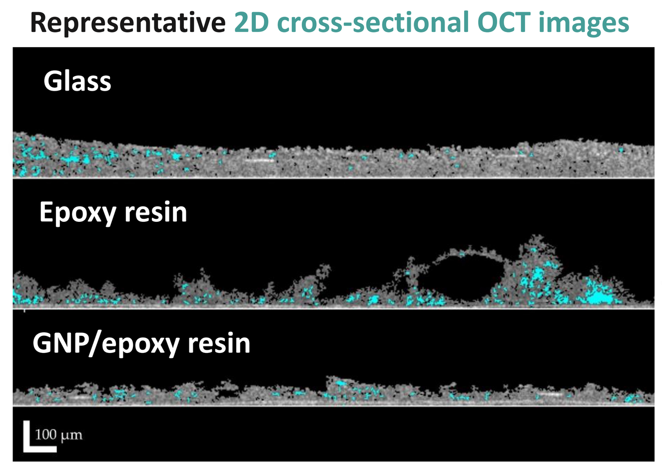



### BIOFILM FORMATION

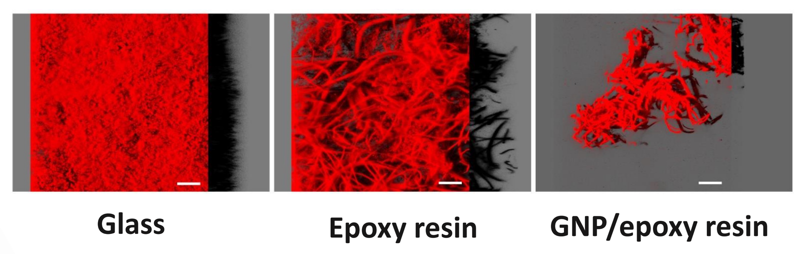



*For each sampling day, different lowercase letters (a, b, and c) indicate significant differences between surfaces ($p < 0.05$).*

Representative **2D cross-sectional OCT images**




Biofilm **three-dimensional CLSM** reconstructions




*White scale bars = 50 µm*

Biofilm **pores** highlighted

## Conclusions

Biofilms developed on the **GNP composite** showed **reduced wet weight**, **thickness**, **biovolume**, and **surface coverage** in the **maturation stage** when compared to the control surfaces (glass and epoxy resin). Moreover, the GNP composite **delayed cyanobacterial biofilm development** and promoted the development of a **less porous biofilm**.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