The Impact of Shear Forces and Surface Hydrophobicity on Coccoid Cyanobacterial Biofilm Development

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INTRODUCTION:

Biofilm formed on **submerged marine surfaces** by **microfoulers** organisms (e.g **cyanobacteria**) play a critical role in the fouling process, causing **increased fuel consumption**, **corrosion**, and **high maintenance costs**. Several parameters have been indicated as **modulators** of **biofilm development**, including **surface hydrophobicity** and **hydrodynamic conditions**. Understanding the conditions affecting biofilm development is **crucial** to develop **new antifouling strategies** and **decrease the economic and environmental impact** of biofilms in **marine environment** [(a)].

MAIN GOAL:

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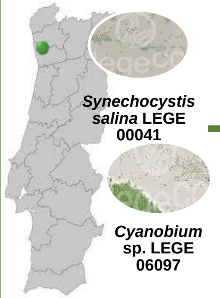
Evaluate the relative importance of **shear forces** and **surface hydrophobicity** on biofilm development by **two coccoid cyanobacteria** with different biofilm formation capacities.

MATERIAL & METHODS:

Cyanobacterial Strains and Biofilm Conditions



Synechocystis salina LEGE 00041

Cyanobium sp. LEGE 06097

Final concentration of **1x10⁸ cells/mL** in VNSS medium

12-well plate with **glass** and **epoxy-coated coupons** (1cm²)

Orbital Incubator

Orbital shaking: 40 rpm and 185 rpm (average shear rates of **4** and **40 s⁻¹**, respectively) [(b)];

42 days of incubation;

25 °C;

1. Surface Hydrophobicity Analysis was performed through the **water contact angle measurements.**

Biofilm Analysis

2. **Biofilm Cells** Each 7 days

3. **Biofilm Wet weight** Each 7 days

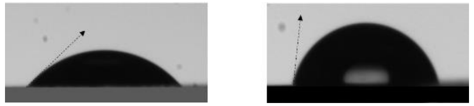
4. **Biofilm Thickness** Each 7 days

5. **Chlorophyll *a* content** Each 7 days

6. **Optical Coherence Tomography (OCT)** On the 42sd day

RESULTS :

1.

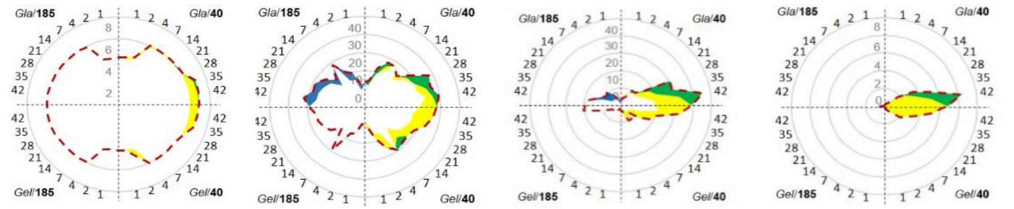


CA = 39.5° ± 3.5 | CA = 90.2° ± 4.3

Figure 1. A representative image of **water contact angle measurement.** Pictures of water droplets on **glass (left)** and **epoxy-coated (right)** surfaces.

Hydrophilic Surface | **Slightly hydrophobic**

2. 3. 4. 5.



Hydrodynamic effect | Combined effect | Surface effect

Figure 2. Radar charts representing **(2.) the number of biofilm cells** (Log cells.cm⁻²), **(3.) biofilm wet weight** (mg), **(4.) biofilm thickness** (µm), and **(5.) chlorophyll *a* content** (µg.cm⁻²), for *S. salina* LEGE 00041. Similar results were obtained foy *Cyanobium* sp. LEGE 6097.

- ✓ The **hydrodynamic conditions** had a **high impact** on increase of **number of biofilm cells, biofilm wet weight** and **thickness**, and **chlorophyll *a* content (yellow area);**
- ✓ The **combined effect** between hydrodynamic and surface hydrophobicity were also verified on the increase in **biofilm wet weight** and **thickness**, and **chlorophyll *a* content (green area);**
- ✓ The **surface hydrophobicity** only had influence on the **biofilm wet weight** and **thickness** at **higher shear (185 rpm) (blue area);**
- ✓ The pure effect of **hydrodynamics** was **stronger** than the **combined effect between surface and hydrodynamic (yellow versus green area).**

6.

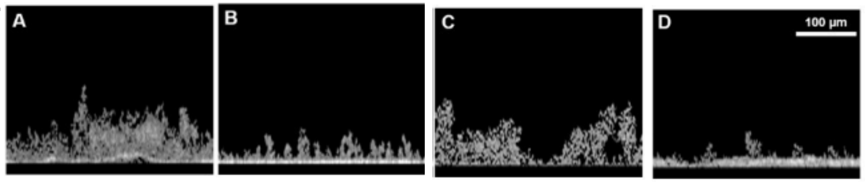


Figure 3. Representative images obtained by **OCT** for ***S. salina*** **LEGE00041 biofilm** (**A-D**) , on day 42, **on glass at 40** (**A**) and **185 rpm** (**B**), and **on epoxy-coated glass** at **40 rpm** (**C**) and **185 rpm** (**D**).

- ✓ **Biofilms** developed **on glass at 40 rpm** were **more prominent**;
- ✓ **Three-dimensional structures** was more noticeable for **biofilms formed at lower shear for both surfaces.**

CONCLUSION:

Shear forces were shown to have a profound impact on biofilm development in marine settings regardless of the fouling capacity of the existing flora and the hydrophobicity of the surface.

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b) Romeu MJ, Alves P, Morais J, Miranda JM, *et al.* 2019. Biofilm formation behaviour of marine filamentous cyanobacterial strains in controlled hydrodynamic conditions. Environmental Microbiology. 21:4411–4424.