27 – 29th September 2023
Biofilm detection and control in the food industry

The potential of Optical Coherence Tomography to analyze biofilm architecture

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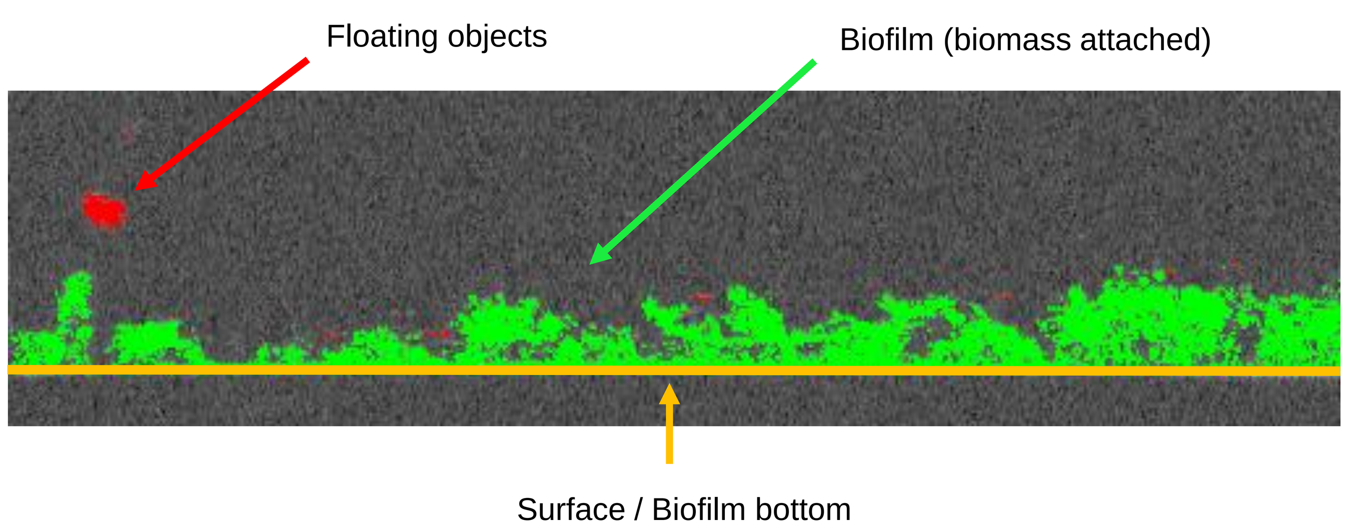
INTRODUCTION

Most imaging methods used to analyze biofilms are *ex situ* and destructive[1]. Optical Coherence Tomography (OCT) is a **non-destructive**, **fast**, and **real-time** approach, allowing biofilm ***in situ*** imaging and the **measurement of different parameters**[2]. Despite the advantages of this optical technique, only a limited set of image processing scripts have been developed explicitly for processing OCT biofilm images. Since the knowledge of biofilm architecture is important to understand all phenomena related to this complex lifestyle, developing novel analysis parameters obtained from OCT imaging to evaluate the biofilm structure is of paramount importance.

MAIN GOAL

Development of novel analysis parameters obtained from 2D and 3D OCT imaging to evaluate the biofilm architecture.

METHODOLOGY [3,4,5]



Biofilm thickness (µm)

- Function of the number of pixels between the bottom of the biofilm and the upper contour line for each vertical line in the image

Contour Coefficient

- Fraction of the biofilm that is exposed to the surrounding medium
- Values close to 1 reflect a homogeneous and flat biofilm, while in biofilms with heterogeneous structures, the values are higher than 1

Total Biofilm Volume (µm^3/mm^2)

- Estimates the total volume of the biofilm

Biovolume (µm^3/mm^2)

- Provides an estimate of the biomass in the biofilm

Porosity (%)

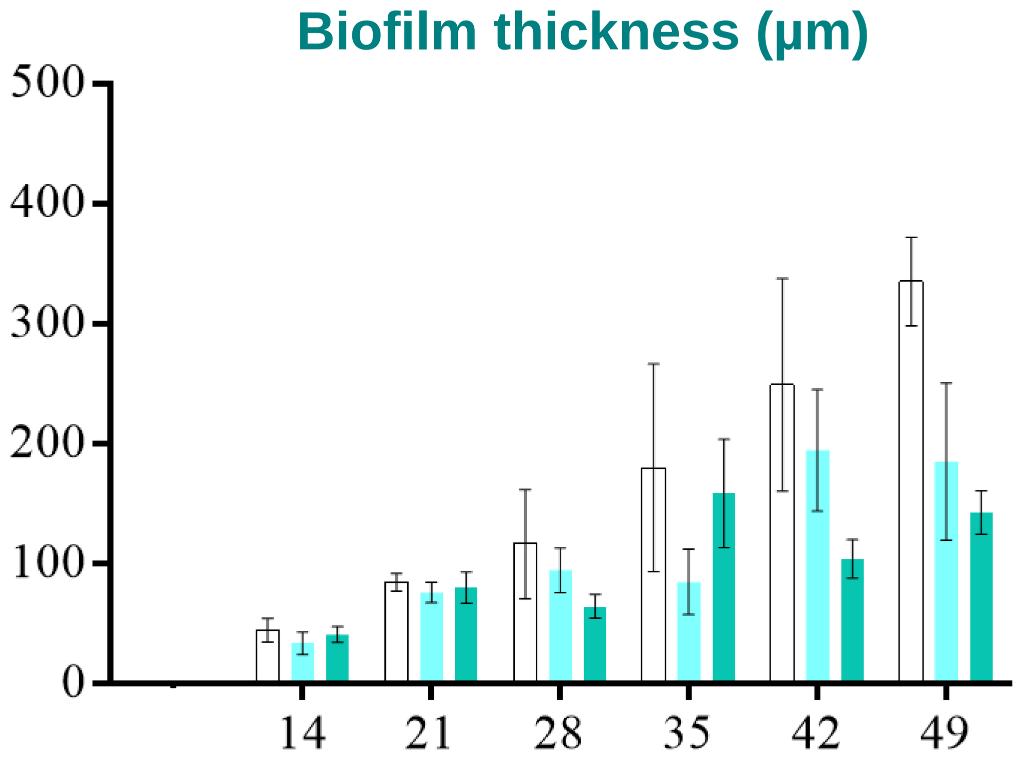
- Ratio between the data obtained from the volume of non-connected pores and the total biofilm volume

Empty spaces (%)

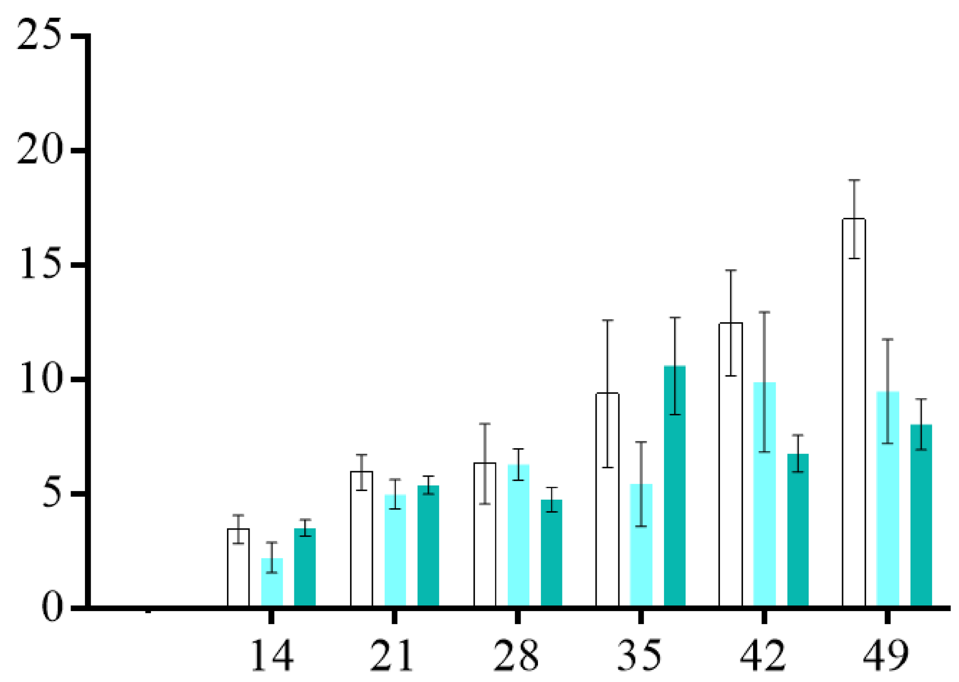
- Since porosity is a 3D concept, this represents the free spaces in 2D imaging

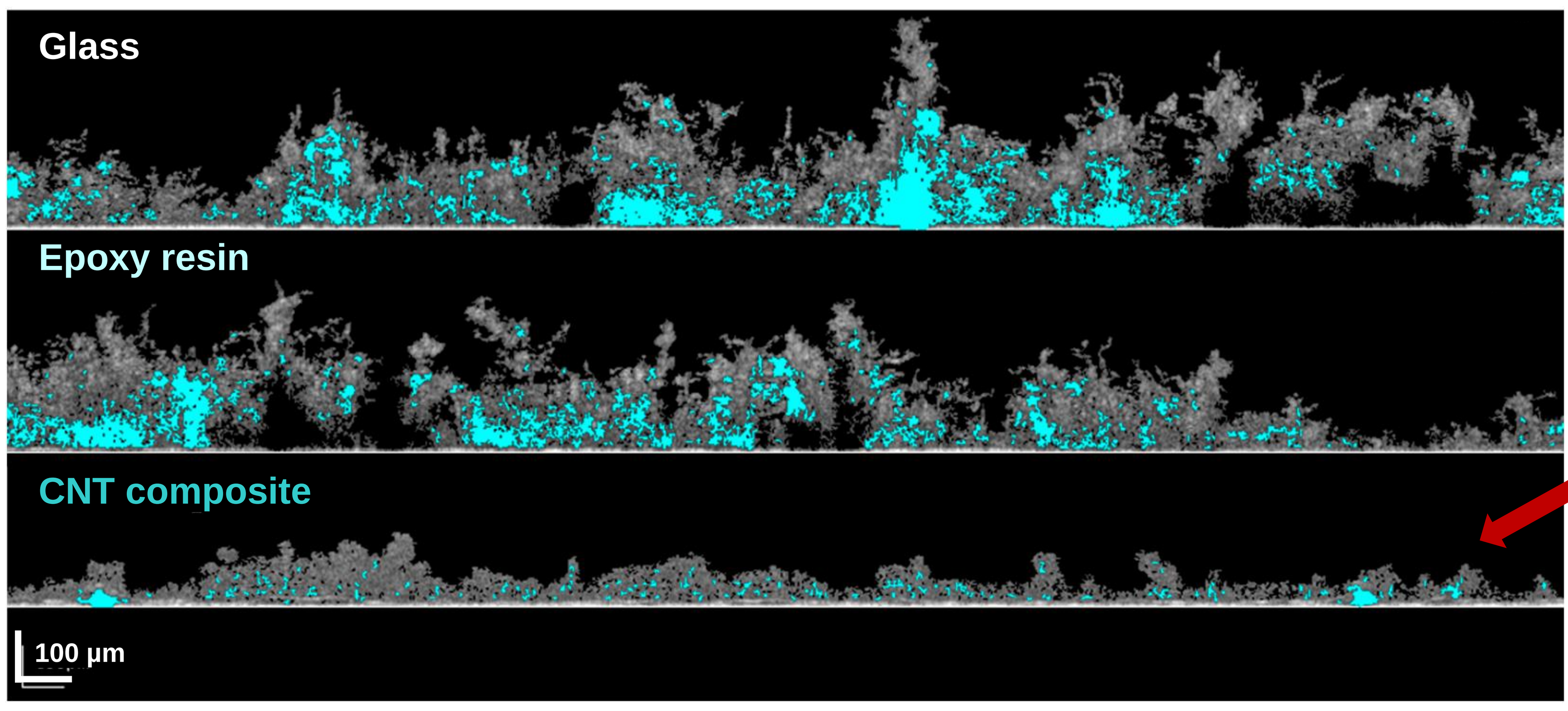
RESULTS [3,4,5]

Biofilm thickness (µm)



Contour Coefficient





Empty spaces on biofilm structure

Homogeneous and **flatter** biofilms

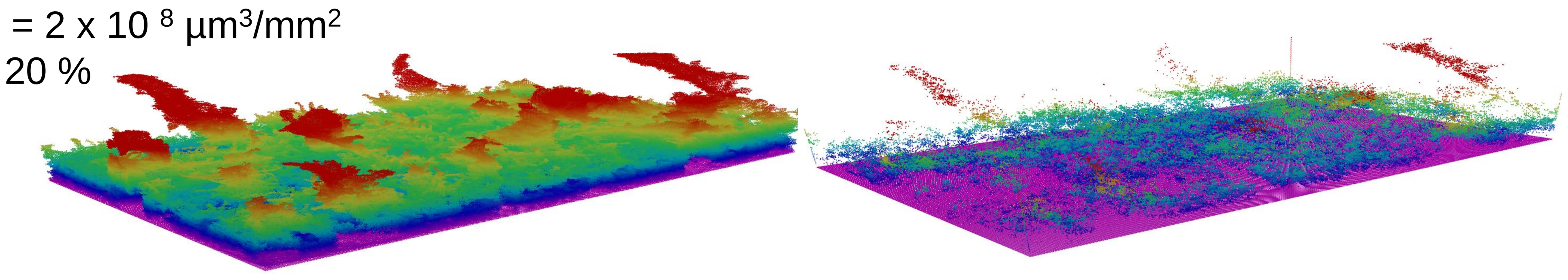
✓ Higher cohesion: detachment of biofilm components by mechanical cleaning may be hampered

3D Biofilm structure

Spatial distribution of non-connected pores

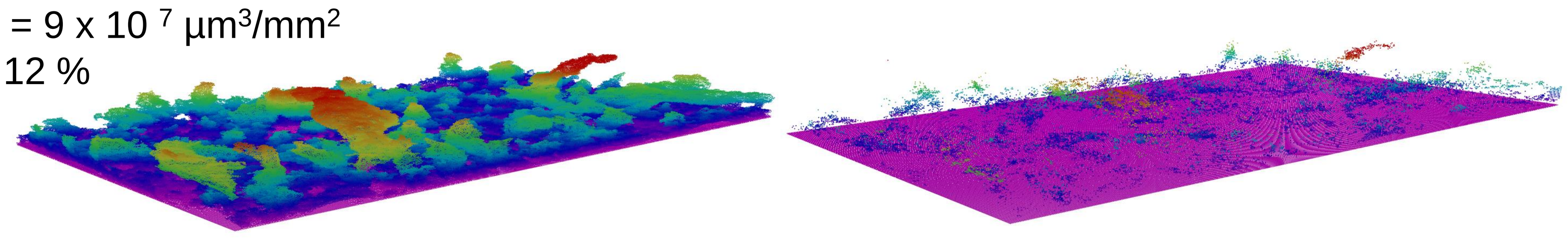
Glass

Biovolume = 2 x 10 ^{8} µm^3/mm^2
Porosity = 20 %



Epoxy resin

Biovolume = 9 x 10 ^{7} µm^3/mm^2
Porosity = 12 %

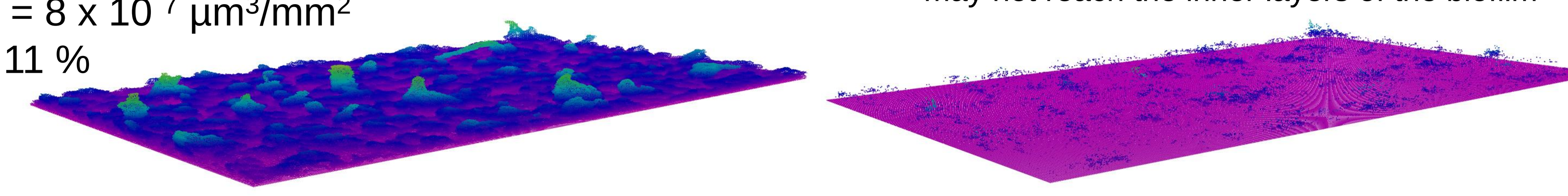


CNT composite

Biovolume = 8 x 10 ^{7} µm^3/mm^2
Porosity = 11 %

Lower porosity

✓ Chemical compounds used for biofouling control may not reach the inner layers of the biofilm



CONCLUSIONS

- ✓ A deeper knowledge of the biofilm requires a **multidisciplinary approach** since distinct techniques provide valuable and complementary information about different aspects of the biofilm's complex structure.
- ✓ The **novel biofilm parameters** obtained from OCT imaging are extremely important when evaluating the **biofilm architecture** and **behavior** under different scenarios, including environmental, medical, and industrial.
- ✓ This imaging tool can be **applied to evaluate the effectiveness of novel antifouling surfaces** and **physical** and **chemical mitigation approaches.**

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ACKNOWLEDGMENTS

This work was supported by LA/P/0045/2020 (ALiCE), UIDB/00511/2020 and UIDP/00511/2020 (LEPABE) and project PTDC/CTM-COM/4844/2020, funded by national funds through FCT/MCTES (PIDDAC); project HealthyWaters (NORTE-01-0145-FEDER000069), supported by Norte Portugal Regional Operational Programme (NORTE 2020), under the PORTUGAL 2020 Partnership Agreement, through the European Regional Development Fund (ERDF); and project SurfSAFE supported by the European Union's Horizon 2020 Research and Innovation Programme under grant agreement no. 952471. M.J.R. and M.L. thank FCT for their Ph.D. grants (SFRH/BD/140080/2018 and 2022.11196.BD, respectively).