Effect of a Carbon Nanotube Composite in the Development and Architecture of Marine Cyanobacterial Biofilms

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INTRODUCTION

Marine biofouling, which consists of accumulation of biological matter on submerged surfaces, causes severe economic, environmental, and ecological impacts[1]. The development of novel, non-toxic antifouling coatings is of great significance for marine applications. Carbon nanotubes (CNTs) have demonstrated antimicrobial and anti-adhesive properties[2], although their mechanism of action is still not clear. While the attachment by macrofoulers is responsible for the main consequences of marine biofouling, the prevention of biofilm development by microfoulers, such as cyanobacteria, reduces the progression of biofouling to the next stages. Therefore, a deeper knowledge of biofilm behavior may enable the development of efficient methodologies to control biofouling. However, few studies focus on longer assays for assessing the effects of CNTs on marine biofilm formation[3]. This work analysed the potential of CNT-modified surfaces to delay long-term cyanobacterial biofilm development in conditions that mimic the hydrodynamics of marine environments[4].

EXPERIMENTAL/THEORETICAL STUDY

1. Surface preparation **-** CNTs were incorporated into a commercially available polymer coating, epoxy resin (3 wt%); 2. Surface characterization **–** surfaces were analyzed by Atomic Force Microscopy (AFM) and Scanning Electron Microscopy (SEM); 3. Biofilm formation – biofilm formation by a filamentous cyanobacterial strain occurred over 7 weeks at an average shear rate of 40 s^{-1}; 4. Biofilm analysis – biofilms were analyzed by Optical Coherence Tomography (OCT) and SEM.

RESULTS AND DISCUSSION

From AFM and SEM analyses, the CNT composite was the roughest surface, presenting CNT agglomerates that form small elevations on the material. Over the 7 weeks, cyanobacterial biofilm growth was more evident on the epoxy resin (control) than on the CNT composite. As in the early stages of biofilm formation, biofilm wet weight, thickness, and biovolume were similar between the surfaces, the results suggest that the CNT composite surface may have a greater antifouling effect on the maturation stage of these cyanobacterial biofilms. Moreover, differences in average roughness seemed to be responsible for the differences registered in the later stages of biofilm development. Consequently, an antimicrobial effect rather than an anti-adhesive effect may explain the impact of CNT-modified surfaces in long-term biofilm layers, since cell-to-cell adhesion, cell reproduction, and production of extracellular polymeric substances may be hampered if cells in the initial layers are damaged[5].

CONCLUSION

CNT-modified surfaces delayed cyanobacterial biofilm development. These biofilms showed reduced wet weight, thickness and biovolume, and were smoother and less porous than those formed on the control surface.

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