M8 CAN MODIFICATION OF SURFACE TOPOGRAPHY REPRESENT A VIABLE METHOD OF BIOFOULING CONTROL IN MARINE ENVIRONMENTS?

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Abstract

Marine biofouling, the unwanted growth of marine organisms such as bacteria, invertebrates and algae on immersed marine structures (e.g. aquaculture cages and ships) represents a costly and troublesome problem for maritime industries. Control of biofouling is a priority for most marine industries, and much effort is expended annually in reducing, removing or attempting to prevent biofouling. At present, the vast majority of biofouling control strategies involve application of biocidal coatings to kill or deter settling organisms. Unfortunately the compounds that are presently incorporated into coatings for this purpose, and many of those that were in use throughout the 20th century, are some of the most noxious compounds released into the marine environment to date (e.g. tributyltin). Use and application of many such compounds in antifouling and biofouling control have now been largely regulated throughout Europe and globally. Therefore a situation has developed whereby very few novel, environmentally-friendly alternative biofouling control strategies have emerged capable of fulfilling the market requirements for replacement antifouling. Modification of surface topography as a means of reducing or preventing biofouling has been proposed as one alternative non-toxic antifouling mechanism that could potentially form part of future multi-action antifouling strategies. In this paper, we present the results of our investigation of biomimetic surface topography as a means of biofouling prevention on small scale (< 1 cm2) surface areas and discuss whether control of surface topography in general represents a viable control strategy for marine biofouling over short timescales.

Keywords: Biofouling, antifouling, biomimicry, topography, diatoms

INTRODUCTION

The economic costs and technical problems created by marine biofouling possibly represents one of the greatest hurdles to transition of maritime industries such as shipping from global polluters to resource-efficient, low greenhouse gas (GHG) emission industries [1]. Loss of revenue, increased transit times and increased fuel costs are often direct consequences of hull fouling for the global shipping fleet [2, 3]. For industries like aquaculture, the economic costs and nuisance aspects of biofouling can often result in significant expenditure and loss of product value [4, 5]. Due to legislative restriction of the compounds that can be utilised in prevention of biofouling (antifouling), the search is on to replace the current biocidal coating based antifouling systems with non-toxic alternative antifouling strategies.

BIOMIMETIC DESIGN OF ANTIFOULING SURFACES

The surfaces of many marine organisms such as fish, sharks, crustaceans and bivalves often exhibit patterned surface topography of micron and sub-micron dimensions [6-8]. Surface structures often exhibit regular periodicity, spacing and aspect ratio (Figure 1). Such surfaces are intriguing from a functional perspective, as the purpose and role of these structures often remains unclear. The key question from an antifouling perspective is whether these surfaces have any role in prevention of settlement, or adhesion, among cells and propagules of biofouling organisms (known as epibiosis when referring to settlement of marine organisms on the living surfaces of other surfaces).

PARAMETERISATION OF SURFACE TOPOGRAPHY

A number of fundamental relationships between surface topography and settlement and adhesion of biofouling organisms are as yet unanswered. While it is established that surface roughness and topography on micron and nanometre scales can affect surface properties such as wettability and surface area, the optimum relationship between parameters such as surface area and surface roughness for control of cell settlement or adhesion are still uncertain [9-11]. In this paper, we present the results of a number of experiments establishing the relationships between surface structure and cell settlement among single celled organisms such as benthic diatoms and bacterial species that may have broader implications for development of non-toxic antifouling surfaces. However it remains to be seen whether such relationships are still relevant when model surfaces are exposed to multispecies biofouling communities in the marine environment. Nonetheless establishment of such relationships can inform further development of effective antifouling surfaces and provide vital clues as to the nature and mechanisms of surface exploration, surface choice, settlement and adhesion mechanisms among biofouling organisms.

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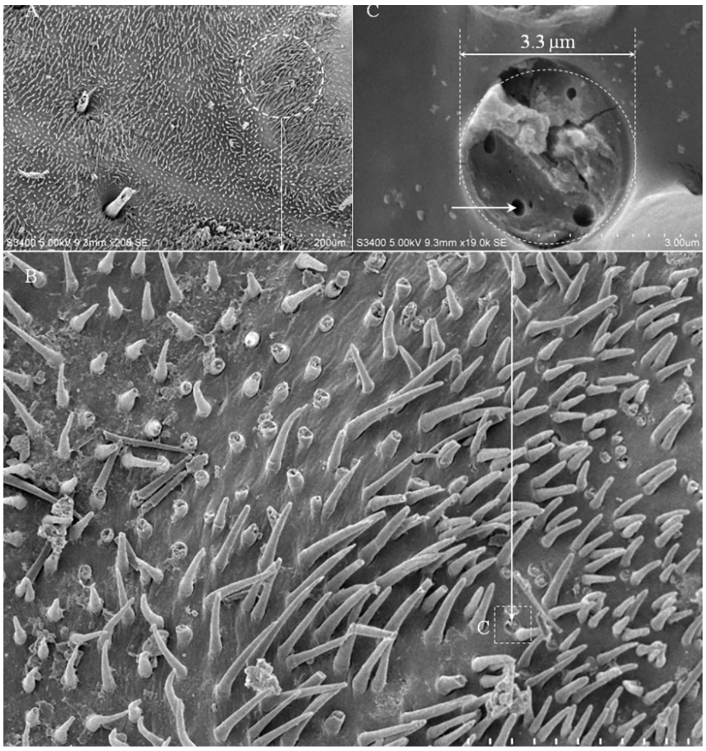

Fig. : The microtrichia of the crustacean Caner pagurus have been previously examined for antifouling potential. Although some evidence of transient biofouling prevention exists for specific biofouling organism groups, the mechanisms and parameters of importance for determining this effect is unclear.