The effect of nanocomposites on the adhesion of *Mytilus edulis* to PDMS surfaces.

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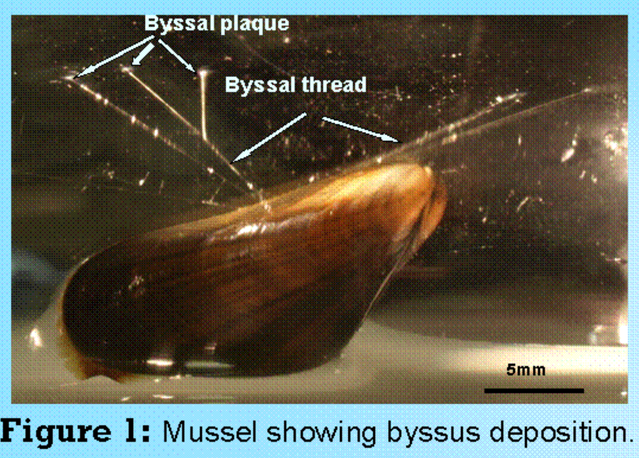

Figure 1: Mussel showing byssus deposition.

Introduction

There is continuing interest in developing new, non-toxic fouling-release (FR) coatings[1] which are designed to reduce the adhesive strength of organisms. Commercial FR coatings have been developed, most based on silicone (PDMS), but a number of issues have limited their utility including their fragility.[1&2] One aim of current research is to improve the strength and FR efficacy of such coatings[3].

Within the EC AMBIO project it has been shown that the addition of small amounts of carbon nanotubes (CNTs) to PDMS improves FR performance with respect to barnacles, bacteria and algae[3]. The addition of natural sepiolite clay (NS) showed variable effects. This present study aimed to examine whether the nanofiller-modified PDMS coatings affected blue mussel, *Mytilus edulis* (Fig.1), settlement choice and byssal morphology.

Materials and Method

Glass microscope slides used for the byssal size experiments (Fig. 2) were coated with PDMS (Sylgard 184) filled with different amounts of NS and CNTs (~150µm thick)[3]. CNT-filled PDMS coatings were also produced on plastic backing to be used in the choice chamber (Fig. 4). Mussels of 11 and 15 mm length (±10%) were used for byssal size experiments while 15 mm long (±10%)mussels were used in the choice assay

Byssal size

Figure 2: Mussels attached to tubing could only sense test surfaces. The surfaces were immersed in seawater and kept at 10^{0}C in constant darkness.

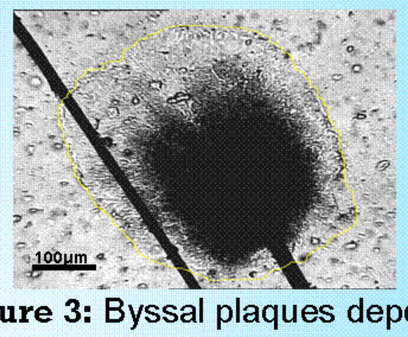

Figure 3: Byssal plaques deposited during 24h were enumerated, areas measured using Image J and mean byssal areas determined for each surface.

Surface choice assay

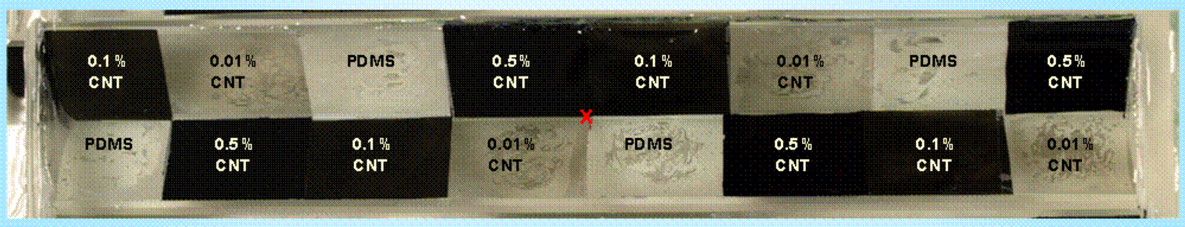

Figure 4: Four PDMS coatings with different loadings of CNTs were arranged in choice chambers. Control chambers were constructed in the same way but all sections were unfilled PDMS. Fifty mussels were placed, one in the centre of each of the chambers (red cross) and left for 12h at 10^{0}C in the dark. The number of byssi deposited was counted and the surface selected was noted.

Dynamic Mechanical Analysis (DMA) was carried out using a Perkin Elmer Pyris diamond dynamic mechnical analyser.

Results

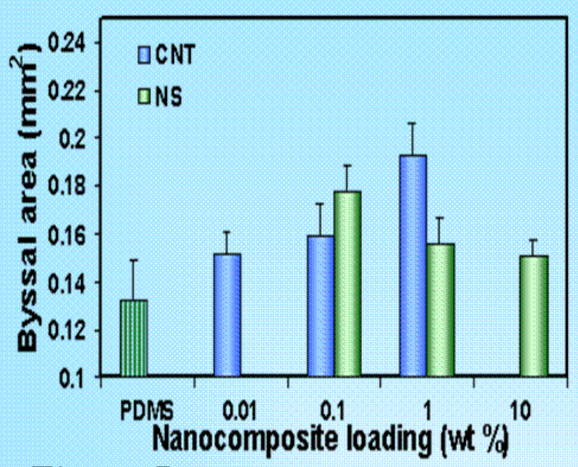

Figure 5: The effect of nanocomposites on byssal size of small (11mm ±10%) mussels (+S.E.)

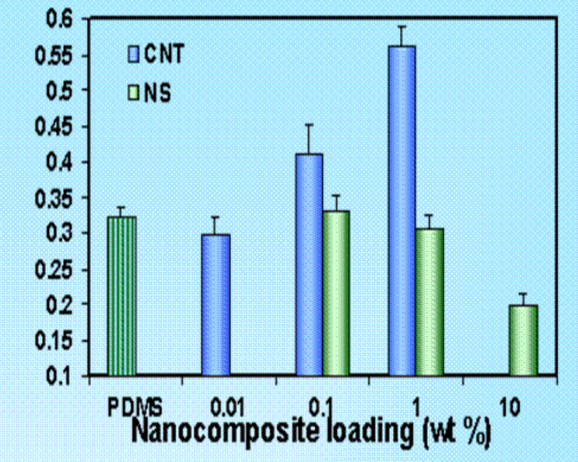

Figure 6: The effect of nanocomposites on byssal size of large (15mm ±10%) mussels (+S.E.)

Carbon Nanotube:

- The apparent trend of increasing byssal size with increasing wt % (Figs. 5&6) was just not significant (p=0.052, regression). Addition of 1 wt% significantly increased the byssal size (p≤0.01 ANOVA).
- Young's modulus increased with increasing CNT loading (Fig. 7).
- CNT addition had no effect on contact angle (CA).

Natural Sepiolite:

- There was no increase in byssal plaque size (p≥0.053 ANOVA, p=0.34 regression).
- Young's modulus showed no clear trend with NS loading (Fig. 7).
- NS addition had no effect on CA.

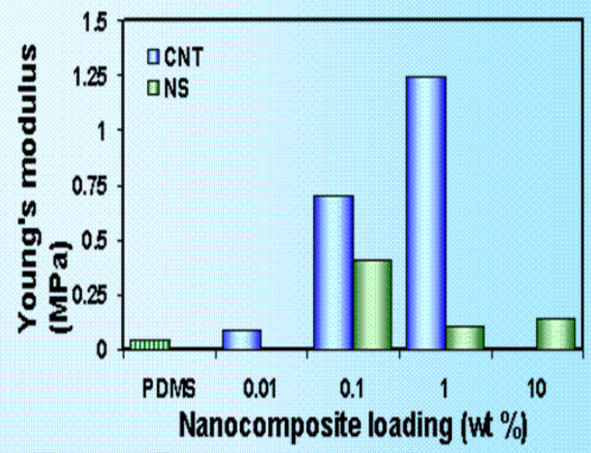

Figure 7: The effect of nanocomposite loading on Young's modulus (determined using DMA).

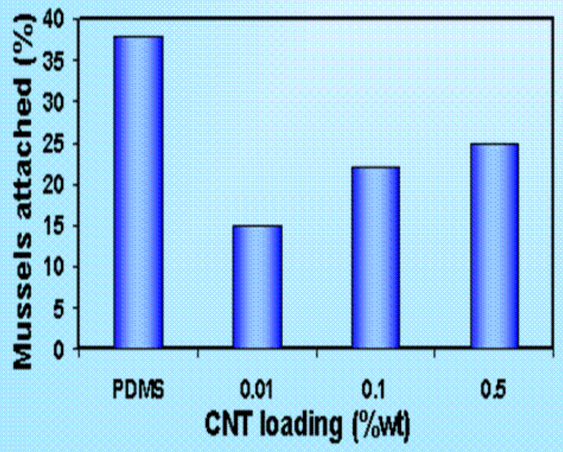

Figure 8: Surface preference of large (15mm ±10%) mussels.

Mussels showed a significant preference for the unfilled PDMS coating over those containing CNTs (Fig. 8; X^2=11.27, p<0.025). Control results (not shown) showed no bias occurred (X^2=3.72 p> 0.1)

Conclusions

- CNTs at the highest concentration (1 wt%) significantly increased byssal size for two size classes of juvenile mussels.
- NS did not significantly affect byssal size at the concentrations tested.
- CNTs at all concentrations tested deterred settlement.
- The relative importance of modulus, which increased with CNT loading, and topography (Fig. 9) to settlement behaviour and plaque morphology is unclear. CA, which has previously been shown to affect byssal area [4], was not a contributing factor here.
- Future studies will aim to examine predispersed CNTs at higher loadings.

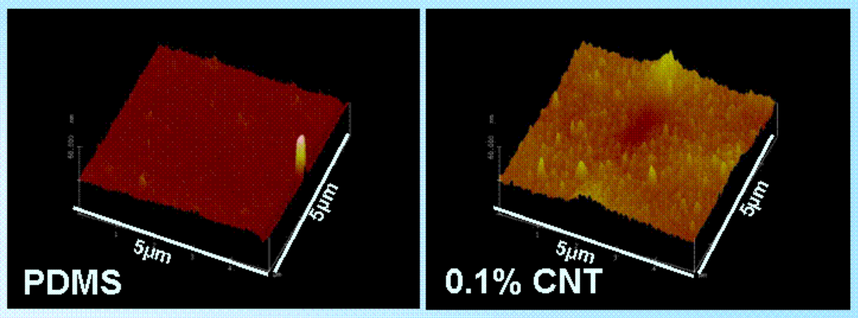

Figure 9: Surface morphology after 1 day of water immersion.

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