Dragonfly wing nanomorphology: mechanobiocidal activity *versus* antibiofouling

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Abstract

Mechanobactericidal and antibiofouling properties are two related phenomena which both result in the minimisation of bacterial contamination. Both strategies are employed in nature; the wings of some insects are lethal to bacteria[1,2], while self-cleaning/antibiofouling properties are well known in the case of plant leaves, esp. those of the Lotus[3]. In both cases, these properties owe to the nanostructure of the lipid cuticles of the organisms in question. Here, we demonstrate that a very fine line exists between the mechanobactericidal and antibiofouling states. The wings of two species of dragonfly, *Hemianax papuensis* and *Diplacodes bipunctata*, are both mechanobactericidal, however the former is ineffective against certain cell types. The chemical compositions of the two wings are essentially identical, although the wings of *H. papuensis* were slightly more hydrophobic (water contact angles were approxiamtely 10° higher). Structural analyses revealed that the significant difference in bactericidal effectiveness arises from very subtle variations in surface nanomorphology. Nanopillar structures on *H. papuensis* wings were larger than those of *D. bipunctata* (70 nm versus 42 nm), and capable of forming secondary, hierarchical structures. This resulted in *H. papuensis* wing surfaces being more effective at trapping air pockets within the nanostructures, which limited the interactions between the wing and bacterial cells. Bacteria were therefore less likely to be ruptured but more easily detached from the wing surface. This work has strong implications in the design of antibiofouling or mechanobactericidal surfaces. Subtle variations in surface nanomorphology can have a substantial impact on material performance; therefore the precise structure produced must be carefully matched to the intended application.

[1]Ivanova, E. P., et al., Small, 2013, 8, 2489-2494.
[2]Ivanova, E. P., et al., Nat. Commun., 2013, 4, 2838-2844.
[3]Bhushan, B., Langmuir, 2012, 28, 1698-1714.