Interactions of algal spores and diatoms with mixed synthetic peptide SAMs.

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Advanced nanostructured surfaces for the control of biofouling
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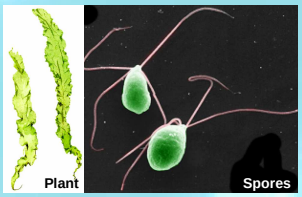
The problem – marine biofouling

Marine biofouling incurs additional costs and environmental impact on the operation of vessels, heat exchangers, fishing equipment, desalination plants and many other facilities, by reduced efficency and increased fuel consumption.

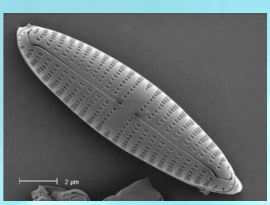
There are about 2500 fouling marine organisms, using a broad range of settlement strategies and bioadhesives. We study the interactions between surfaces and marine organisms in terms of physicochemical cues, in order to understand settlement behaviour and ultimately to improve anti-fouling properties of surfaces.

Biological tests

We have studied the attachment of a major ship fouling alga (*Ulva*) and a diatom (*Navicula*) to the mixed peptide SAMs.



Ulva linza

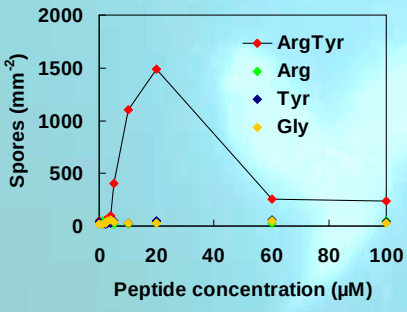


Navicula perminuta

Ulva plants release spores which swim with the aid of flagella. As a suitable surface for settlement is located, a physiological change into a plant is started. *Ulva* spores lack cell walls, and expose the plasma membrane to the environment, while the *Navicula* cells are encased within a silica cell wall.

The peptide SAMs were incubated in *Ulva* spores or *Navicula* cells for 1 h, whereupon the density of settled (attached) cells was determined.

Incubation assay



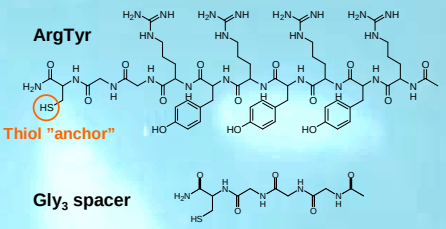
Up to 20 μM, free ArgTyr peptides in solution stimulate the settlement of Ulva spores. Above 20μM, spores lysed (died). No such effects were observed for the free amino acids of which the ArgTyr peptide is composed.

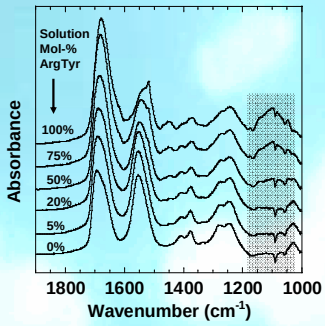
Mixed peptide SAMs

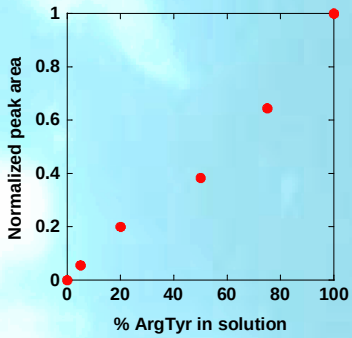
A synthetic cationic arginine-rich peptide is used to form mixed SAMs on gold substrates (via a thiol linker), with a shorter spacer molecule. IRAS, wetting and ellipsometry data demonstrate that the peptides form organised monolayers.

Mol-% ArgTyr	Thickness (Å)	Contact angles (θ_a)
0%	13.1	41°
5%	16.5	46°
20%	16.8	47°
50%	21.5	51°
75%	23.3	52°
100%	26.2	44°

(θ_r < 10 for all mixtures)



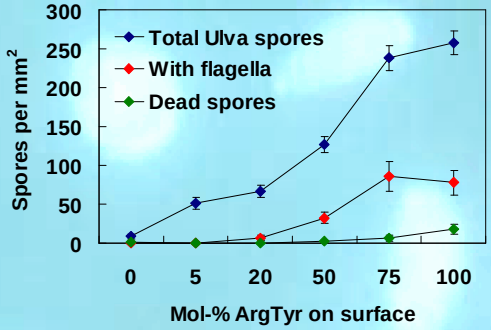


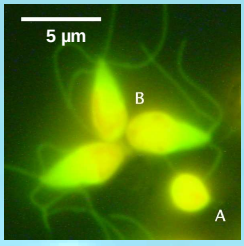


FTIR data for mixed ArgTyr/spacer SAMs. Peak areas within the shaded region were used to estimate the surface fraction of the ArgTyr peptide for different solution fractions (right).

Settlement results

The density of settled *Ulva* spores increases with bound ArgTyr content but many of the 'settled' spores retained their flagella indicating that they had not gone through the normal settlement process; these spores probably died. *Navicula* cells, however, are unaffected by the presence of the ArgTyr peptide; cell attachment is not altered and no cells died. This difference is probably due to the diatom cell wall preventing the bound ArgTyr peptide from contacting the plasma membrane.





Normally settled (A) and 'stuck' (B) spores, with flagella still attached.

Summary: The ArgTyr peptide interacts specifically with *Ulva* cell membranes, promoting adhesion to a surface, but also preventing it from going through its normal settlement physiology, and ultimately causing cell death.