

Variation of Ionic Strength in Alginate Adsorption

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Introduction

Biofilm formation poses a serious problem in many arenas. We are studying nucleation of model biofilms via adsorption of polysaccharides (in this case, alginate) to protein conditioning films.

This study explores the effect of solution ionic strength on the adsorption of alginate. In the simplest case, higher ionic strength would lead to greater screening of negative charges between adjacent alginate molecules, allowing greater coverage.

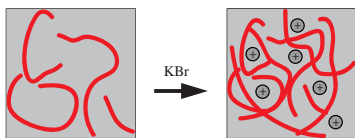


Figure 1. Depiction of the hypothesis that ions in solution screen repulsive interactions between neighboring alginate molecules.

Experimental

Biofilm formation was modeled using the synthetic protein, poly-L-lysine (PLL), and the polysaccharide alginate. Two types of silica derivative surfaces were used as substrates, each with different surface properties. The hydrophilic silica surface is terminated with negatively-charged silanol groups, and the hydrophobic surface is terminated with alkyl chains.

The surface was conditioned with a layer of protein, PLL, to mediate polysaccharide adsorption. The ionic strength of alginate solution was controlled with potassium bromide. Film thickness was measured with ellipsometry, and surface wettability was measured with contact angle goniometry.

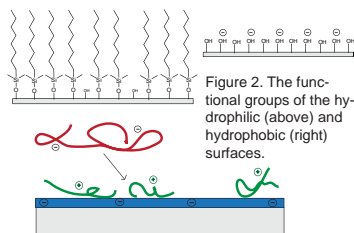


Figure 3. Adsorption of positively charged alginate (in red) to negatively charged PLL (in green) on the silica surface.

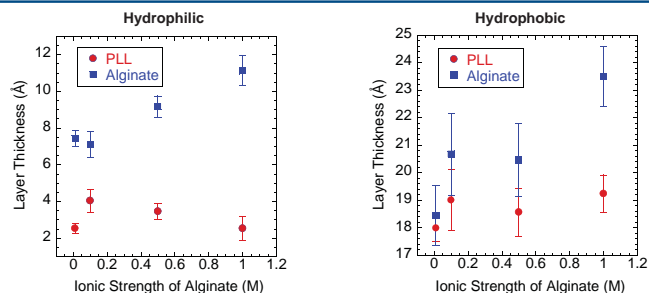


Figure 4. Ellipsometry data of layer thickness for PLL and alginate adsorption to the hydrophilic (left) and hydrophobic (right) surfaces.

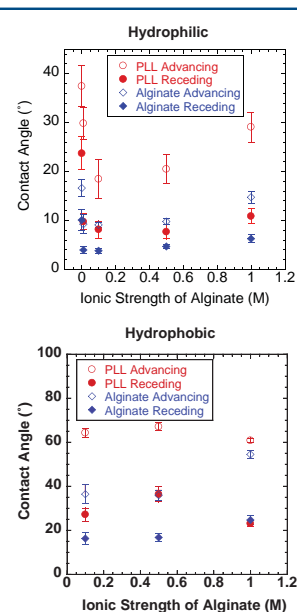


Figure 5. Advancing and receding contact angle data for the adsorption of PLL and alginate to the hydrophilic (above) and hydrophobic (below) surfaces.

References

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Ellipsometric data of film thickness show a clear trend of increasing alginate adsorption with increasing ionic strength on the hydrophilic surface. Because PLL coverage is constant in these experiments, this suggests that on the hydrophilic surface either 1) alginate coverage was not maximized on PLL-covered areas at low ionic strength, or 2) at higher ionic strength alginate is able to adsorb to bare regions of the surface, perhaps via bridging interactions with a positive (K⁺) cation between the negatively charged alginate and the negatively charged silanol surface. In contrast, there is no increase in alginate adsorption on the hydrophobic surface until very high ionic strength, where alginate complexes may be forming.

The contact angle data for the hydrophilic surface do not show substantial changes for alginate at different ionic strengths, which suggests the film heterogeneity is not affected by ionic strength. This is more consistent with increased alginate adsorption on the PLL-covered regions of the surface (case 1 above). In this case, the areas of bare surface still present after PLL adsorption would remain bare after alginate adsorption. For the hydrophobic surface, an increase in advancing angle of alginate at the highest ionic strength is consistent with the clumping mentioned above, which would expose more (high contact angle) bare surface.

Conclusion

Ionic strength does not seem to have a dramatic effect on alginate adsorption, which is largely PLL-mediated on both surfaces studied. Additional information about film morphology will be provided by atomic force microscopy studies. In both cases, however, it appears that alginate interaction with the bare surface is minimal, and that the limited amount of alginate adsorption (particularly on the hydrophilic surface) is a function of initial PLL coverage on these surfaces.

Acknowledgements

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