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Why Are Biofilms Always So Sticky?

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Among the many advantages conferred by biofilms to the inhabiting microorganisms is an ability to stick to solid surfaces. Interestingly, this ability transcends the environmental conditions in which the microbes find themselves. From biological tissue to soil aggregates to sediments in both freshwater rivers and oceans, biofilms are really good at sticking to stuff! Furthermore, this stickiness lasts long after the biofilm creators are dead and gone. For instance, the coating of sand particles by clay minerals and estuarine ecosystems has been linked to prior microbial activity. Thus, biofilm polymers are thought to play a critical role in the formation of the hierarchical structures that are thought to be responsible for the sequestration of organic carbon by sedimentary media.

Frustratingly, the ability of biofilms to stick to surfaces is still not completely understood. This is because stickiness is a result of nanoscale physicochemical processes which are difficult to explore experimentally in hydrated soft matter systems. Here, we aim to overcome this challenge by using molecular dynamics (MD) simulations to elucidate the nanoscale properties of biofilms that underlie their ability to wet (and stick to) solid surfaces. Our simulations consist of a gel droplet of sodium alginate (a model biofilm polymer) at varying water contents (<95% water) in contact with an atomically smooth clay surface. The resulting simulations provide detailed visual and quantitative insight into the interaction of alginate gels with a dry surface. Furthermore, our results suggest that biofilm stickiness is not solely a result of polymer-solid interactions, but rather emerges from the impact of the polymer solution on the wetting dynamics of the water in which it's dissolved.