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The role of substrate mechanics in osmotic biofilm spreading

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Bacteria invade surfaces by forming dense colonies encased in a polymer matrix. Successful settlement of founder bacteria, early microcolony development and later macroscopic spreading of these biofilms on surfaces rely on complex physical mechanisms. Recent data show that on soft hydrogels, substrate rigidity is an important determinant for biofilm initiation and spreading, through mostly unknown mechanisms. Using a thermodynamically consistent thin-film approach for suspensions on soft elastic surfaces supplemented with biomass production and an imposed osmotic pressure we investigate in silico the role of substrate softness in the osmotic spreading of biofilms. We show that spreading is considerably slowed down on soft substrates and may be completely halted depending on the biomass production rate. We find, that the critical slowing down of biofilm spreading on soft surfaces is caused by a reduced osmotic influx of solvent into the biofilm at the edges, which results from the thermodynamic coupling between substrate deformation and interfacial forces. By linking substrate osmotic pressure and mechanical softness through scaling laws, our simple model semi-quantitatively captures a range of experimentally observed biofilm spreading dynamics on hydrogels with different architectures, underscoring the importance of inherent substrate properties in the spreading process.

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Sitzung Einordnung: Short Talks