Polymer hydrogels as models for bacterial ingress, microstructuring and colonisation

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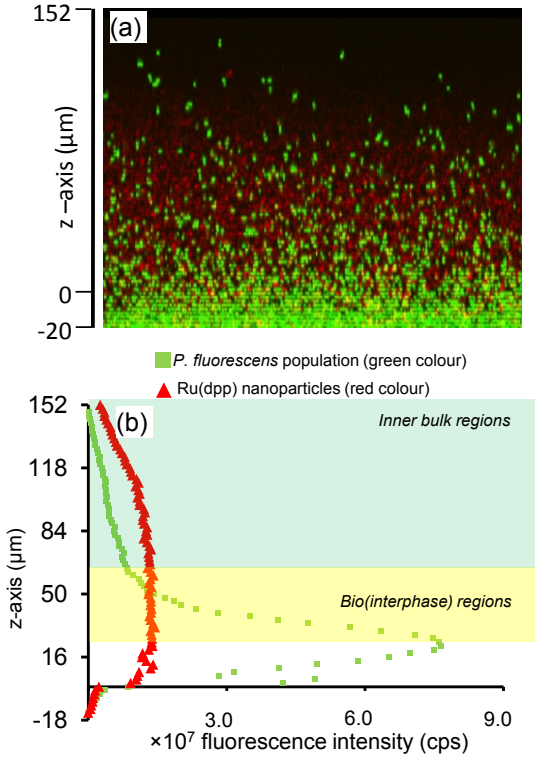
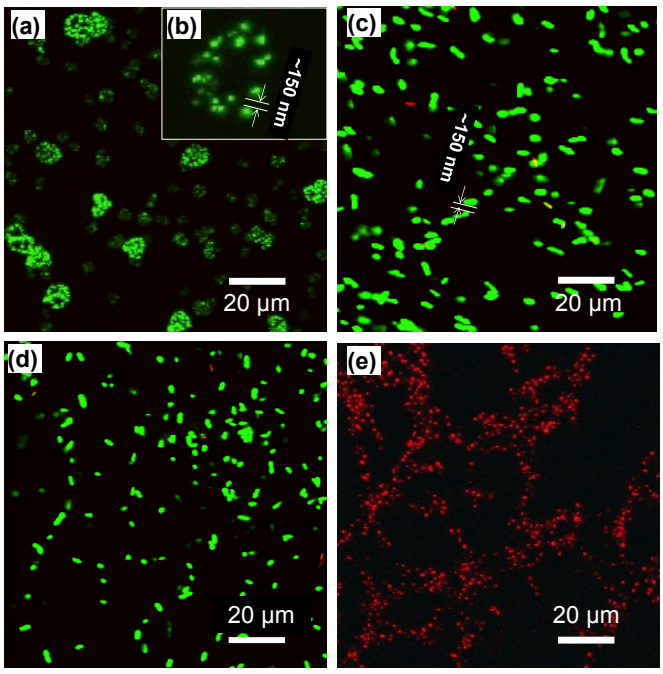
Abstract

Studies of microbial interactions during motility, micro-structuring and colonisation have predominately been limited to surface associated bacteria involving materials such as semi-solid biomolecular hydrogels and thin liquid films. Recently, these surfaces have been extended to synthetic polymers where they provide defined chemistries and structural properties. However, precise details of microbial ingress into the confined fluid volume of synthetic 3-D hydrogel networks and the subsequent microstructuring and colonisation remain to be defined. Here, we show that Gram-positive and Gram-negative bacteria internally populate mesoporous polyacrylate hydrogels by quantifying: the dynamic advancing population front and the resultant spontaneous self-organisation into well-defined clusters and micro-colonies. Polymer chain conjugated fluorescent nanoparticles indicated that both bacterial clusters and micro-colonies associated directly with the polymer chains of the mesoporous hydrogel. Protonation of the K-polyacrylate, made chains more hydrophobic and globular in conformation, reducing the swelling of the hydrogel by half. However, the bacterial population increased by 30% indicating the dominance of hydrophobic and viscoelastic interactions as well as the cation chemistry within the confined fluids of synthetic polymer hydrogels despite pore size reductions of 50%. Synthetic polymer hydrogels having a range of porosities when swollen together with controllable chemical and structural functionality can potentially offer well-defined microenvironments for bacterial populations in advancing biotechnologies such as inoculants and substrates in the production of therapeutic agents.



Defining the interphase and inner bulk regions of the hydrogel



Microstructure of bacteria within the inner bulk region