428f Modeling Cell-Matrix Interactions and Nutrient Transport in Cell Scaffolds Possessing Inverted Colloidal Crystal Geometry

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Recently, the biocompatibility of cell scaffolds based on inverted colloidal crystal (ICC) geometry to support and grow biological cells, like human hepatocellular carcinoma and human bone marrow cell cultures, has been demonstrated (Kotov et. al., 2004, Langmuir, 20(19); 7887-7892). These scaffolds are made by infiltrating a close-packed lattice of self-assembled polystyrene beads with silica gel or hydrogel, followed by annealing, and dissolving the skeletal polystyrene beads. The resulting scaffolds are porous, regular and exhibit a high degree of uniformity and 3D organization. This enables computational modeling to study, for example, the transport properties of these scaffolds. We use Brownian dynamics and kinetic Monte Carlo simulations to characterize the resistance offered by the ICC scaffolds to the diffusion of nutrients and waste products. For a typical configuration of the scaffold, we find that the effective diffusivity of a nutrient species decreases by a factor of 3, approximately. Adequate cell-matrix contacting/signalling is an important criterion to ensure the growth and proliferation of cell-cultures on tissue-engineering scaffolds. Idealizing the cell as a hard sphere, we use simplified Brownian Dynamics simulations to compute the extent of cell-matrix contacting, and specify design principles and optimal geometries. Our modeling can explain experimental observations in which cell cultures thrive only in a narrow window of geometrical specifications. Finally preliminary results using a Cellular Potts Model to simulate non-uniform cell shapes will be presented.