

191e Perfluorocarbons for Enhanced Oxygen Transport in Tissue Engineering Devices

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In tissue engineering devices, cell viability and functionality is highly dependent on dissolved oxygen levels. Hypoxic or hyperoxic conditions can have detrimental effects on cell survival. In cell encapsulation systems, oxygen transport is often limited due to the presence of additional barriers. Consequently, encapsulated cells/tissues can easily suffer from oxygen deficiency. Perfluorocarbons (PFCs) have been utilized as oxygen vectors both in vivo (e.g., blood oxygenation during surgery) and in vitro (e.g., increase media dissolved oxygen levels in bioreactors). However, most studies address oxygen transport by freely moving PFC emulsions. Few studies have focused on enhancement of oxygen transport using embedded PFC droplets in cell encapsulation matrices (e.g., hydrogels).

In previous studies, we have demonstrated enhancement of cellular metabolic activity through inclusion of PFCs in alginate encapsulation devices. In this study, we have developed a simple cubic model to predict oxygen diffusivity in alginate/PFC composite systems. Inclusion of PFCs had a positive effect on oxygen diffusivity as compared to alginate alone. PFC content and droplet size are key factors in controlling diffusivity. A diffusion-reaction model using Michaelis-Menten kinetics with theoretically obtained oxygen diffusivities was developed. This model was verified through experimental measurements of oxygen profiles in alginate/PFC devices and oxygen uptake rates using a perfusion reactor developed in our laboratory. Oxygen profiles were obtained using a ruthenium complex (Ru(dpp)₃Cl₂, tris(4,7-diphenyl-1,10-phenanthroline) ruthenium(II) dichloride) incorporated in the encapsulation matrix that allowed for visualization and quantification of dissolved oxygen levels via fluorescence microscopy. Additionally, we have collected metabolic data using the liver HepG2 cell line (e.g., glucose consumption, lactate production) to demonstrate enhancement of aerobic metabolism due to the presence of PFCs. All of these data taken together suggest that inclusion of PFCs in cell encapsulation/tissue engineering devices can have a positive impact on cellular function.