Simulation of oxygen release from an oxygen delivery scaffold

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Abstract

Oxygen concentration has great influence on cell proliferation, differentiation, and gene expression and is essential for the normal activities of mammalian tissues and cells. However, hypoxia and even anoxia can occur during tissue engineering and tissue preservation, because of the extremely low solubility of oxygen. We have developed an oxygen delivery scaffold (ODS) to supply oxygen sustainedly for tissue engineering and tissue preservation. In our ODS, we employed CaO_2 as the oxygen generating agent, which decomposes upon contact with moisture and produces oxygen. [1] Since the decomposition rate of CaO_2 is very fast, it is necessary to reduce its decomposition rate. We chose hydrophobic polycaprolactone (PCL) to reduce the decomposition rate of CaO_2. CaO_2 powders were mixed with PCL in chloroform and then the liquid evaporated at room temperature to form CaO_2-PCL composites. Therefore, PCL inhibits the decomposition of CaO_2 by repelling H_2O and decreasing the surface area of CaO_2 particles. To further control oxygen release, the CaO_2-PCL composite was encapsulated in alginate hydrogel, which reduces the amount of H_2O available to CaO_2 and serves a barrier for oxygen diffusion as well [2]. Using the ODS described here, we successfully rescued primary human fibroblasts under the anoxic environment. The preliminary experimental results also show the ODS was capable of preserving aortas for up to one week at the physiological temperature. Nevertheless, it is difficult to measure the oxygen gradient from the ODS towards cells, although it is very important information for us to understand the effects of oxygen tension on cells. There are different ways for oxygen measurement, however, very few of them are able to measure oxygen gradient within small volume of liquid. We believe mathematical simulation can be a good method to describe the oxygen diffusion process from ODS towards cells and predict the oxygen gradient generated by ODS. We currently work empirically and knowing the key parameters would be a great help in moving forwards, for example by changing the surface are: volume ratio, thickness of diffusion barriers and so forth.

Reference

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