DESIGN AND SIMULATION OF A NOVEL PARALLEL PLATE BIOREACTOR FOR REAL TIME MONITORING OF ENDOTHELIAL CELLS USING CFD

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Introduction

During the last few years, tissue engineering has encountered several problems to recreate the environment to which cells are exposed to. A bioreactor is the perfect tool to mimic these conditions, allowing in vitro experiments [Dermenoudis, 2010].

In this paper, the design of a parallel plate bioreactor to evaluate the distribution, movement and cell orientation under precise conditions of shear stress is proposed. Computer simulations were made to corroborate the correct design of the bioreactor and to predict the behaviour of certain parameters such as heat transfer, flow profile and shear stress in the bioreactor's flow chamber (FC).

Methods

A parallel plate bioreactor type was chosen due to its versatility, and capability to provide the necessary stimuli to endothelial cells to differentiate. A modular design shown in fig. 1 provides the capability to change the flow chamber geometry to simulate different physiological situations, simple water heating system and live visualization if mounted under the microscope during the experiment.

To corroborate the correct behaviour of the bioreactor several computer simulations were made with the use of the FE (finite elements) and CFD (computer fluid dynamics) technique [Benim, 1985]. These techniques helped to estimate critic parameters for in vitro experiments like heat transfer, flow profile and shear stress conditions in the walls of the FC.

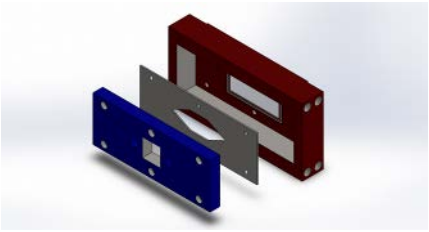

Figure 1: Design of a parallel plate bioreactor.

Results

With the processing of the raw data obtained it was made clear that the design coped with all the necessary conditions for endothelial cells to grow and differentiate. A proper temperature was reached within seconds, no turbulence was observed in the area of interest, and a shear stress curve was made to relate the input flow with the stimuli generated shown in fig. 2.

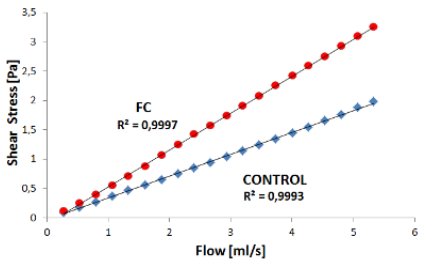

Figure 2: Shear stress results vs. ideal geometry.

Discussion

With the processing of the results it is observed that the temperature needed is reached within a short amount of time. The lack of turbulence in the FC provides a laminar flow in the cell-seeding area thus allowing a model to estimate the shear conditions to which the cells will be exposed [Traub , 1998]. It is shown that the use of computer simulation to design the bioreactor is a mandatory step in the design of a bioreactor and proves its value when optimizing the conditions for the breeding of the cells.

References

Dermenoudis *et al*, Advanced Engineering Materials, 11:B592-B608, 2010.

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