Temperature control in 3D sound-induced morphogenesis (SIM) technology

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Thesis advisors: Prof. Dr. Jörn Justiz, Roman Amrein
Expert: Raja Yazigi (Netsensing Technology Sàrl)
Industrial partner: mimiX Biotherapeutics Sàrl, Neuchâtel

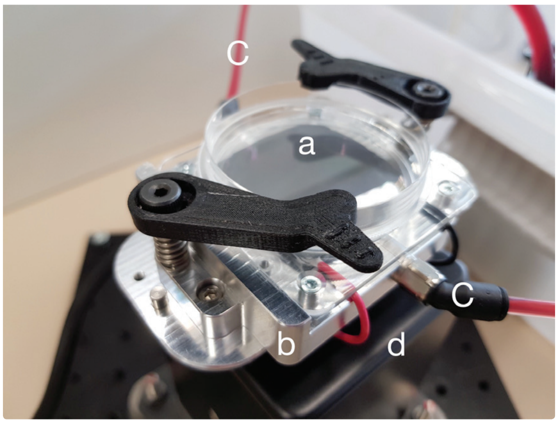
Cell shaping, via 3D bioprinting, allows the creation of tissue constructions. During this process, temperature regulation is very important, as cells start to die at 40°C and above. The objective of this project is to implement temperature measurement and regulation within the cell environment.

Introduction

3D printing methods applied in the field of bio-manufacturing have the disadvantage of being slow, as several minutes are required to produce a single cell layer. The machine developed by the company Mimix biotherapeutics, makes it possible to generate different cellular patterns in a hydrogel. This is achieved in a matter of seconds using induced vibration technology. The Petri dish in which the hydrogel is contained is placed on a Peltier module (thermoelectric element) which allows its contents to be heated/cooled. The heat exchange platform evacuates the energy accumulated on the side in contact with the Peltier module. Within the platform there is a water channel which allows the heat to escape.

Motivation

The current prototype allows heating/cooling of the contents of the Petri dish. But there is no temperature control, neither in the Petri dish nor on the thermoelectric module. Temperature control is necessary, as the Peltier module must not exceed a temperature of 80°C or it will be damaged, and the cells in the hydrogel cannot survive temperatures outside the 4-40°C range. The challenge of measuring the temperature of the cells is that they are in a sterile environment and this must remain so throughout the printing process.



a. Petri dish with hydrogel, b. Platform for heat exchange with Peltier element, c. Water in/out, d. Vibration generator

Objective

The heat exchange platform is still at the prototype stage and needs to be modified. The objective is to improve the mechanical design in order to have a more efficient thermal evacuation and to be able to add temperature sensors on both sides of the Peltier element. In addition, the integration of temperature measurement within the Petri dish is necessary to maintain the cells contained in the hydrogel at a desired temperature. All temperature control and regulation will be done by a PID system programmed on a microcontroller.

Methods

Several concepts have been devised to measure and maintain temperature in a sterile environment. Different thermal sensor technologies were compared. The final solution consist of an infrared temperature sensor, which has the advantage of being contactless, and a thermocouple, which will be housed in the Petri dish, for indirect contact measurement with the biomaterial. Subsequently, the mechanical design of the new platform must incorporate, the integration of thermal protection sensors and the improvement of the water passage channel. Finally, the electronic part was developed in order to integrate the microcontroller that will manage the system, notably the temperature measurement and the regulation of the different units.

Results

At the end of this project, the expected result is a complete system comprising the new platform, the thermal monitoring of the Peltier, the programming of the system for the measurement and regulation of the Cells‘s temperature in the Petri dish.

Saverio D'Amico
079 771 77 95
s.damico@hotmail.it