CERIS : Civil Engineering Research and Innovation for Sustainability

Advanced microfluidic devices for cell culture and point-of-care immunoassays

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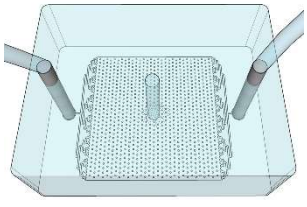
Summary

The application of microfluidics in biomedical research has been instrumental in pushing the boundaries of what is possible in terms of experimental design, analysis, and development of novel healthcare solutions. As technology continues to advance, microfluidics plays an increasingly important role in shaping the future of biomedical research and healthcare. Microfluidic systems allow the miniaturization and integration of complex laboratory processes onto a single chip. This integration can lead to reduced sample and reagent consumption, faster analysis times, and the potential for high-throughput screening. Furthermore, microfluidics provides a controlled environment for studying cells and tissues in vitro. Researchers can mimic physiological conditions more accurately, leading to advancements in understanding cell behavior, tissue engineering, and drug testing. Additionally, microfluidic devices are well-suited for developing portable and rapid diagnostic tools. This has significant implications for point-of-care testing, especially in resource-limited settings, where quick and accurate diagnostics are crucial.

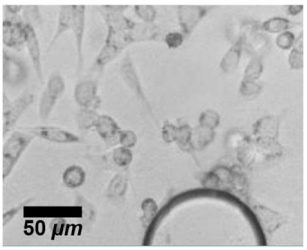
The objective of this doctoral research was to develop versatile microfluidic systems that enhance biomedical research and offer innovative tools for healthcare systems. This thesis pursued two directions to achieve these microfluidic systems: 1) In the first, a microfluidic platform for mammalian cell culture and study of biological interactions with M13 bacteriophages was developed. The cell culture platform was further integrated with thin film amorphous silicon photosensors and with another microfluidic platform for the detection of adenylate kinase (AK) in two different collaboration works. Moreover, the knowledge acquired with this platform led to the first development steps of a microfluidic cell-chip for an in vitro hepatic disease model. The second direction of the thesis delved into the development of a microfluidic capillary platform with hydrophilic polydimethylsiloxane (PDMS) for point-of-care immunoassays. The device was successfully applied to the fluorescence and colorimetric detection of Infliximab, a therapeutic antibody used in the treatment of chronic inflammatory diseases.

Keywords

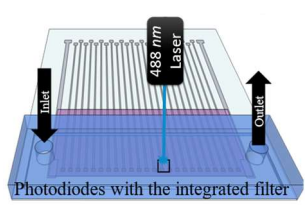
Microfluidic, cell culture chips, hydrophilic polydimethylsiloxane (PDMS), capillary, Point-of-Care.



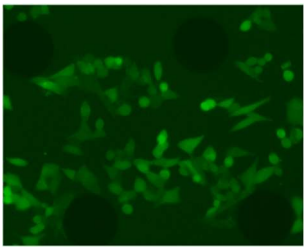
PDMS Device for cell culture



HCT116 Cells culture in the device

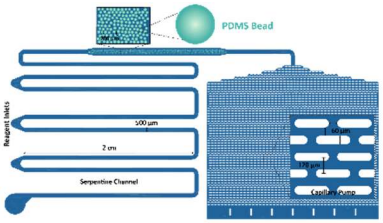


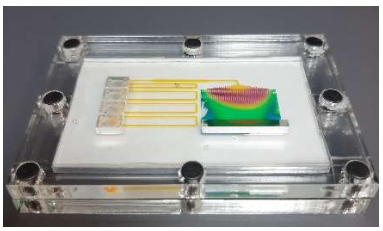
Photodiode integration



Labelled M13 phage capture

Microfluidic cell culture device for M13 Bacteriophage capture





Capillary design (top) and food coloring proof-of-concept (bottom).