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Novel Microfluidic Strategies for Droplet Generation and Flow Control with Applications in Biotechnology

Abstract

The outstanding advancement of microfluidics during the past few decades has progressed from the early phases of pure development of microfluidic technologies to its widespread use as a versatile instrument for multiple scientific disciplines.
Simultaneously, biotechnologies have been progressively evolving towards innovative directions, with an increasing emphasis on tailoring medical treatments to the patient. This paradigm shift toward tailored therapies and personalized medicine provides new prospects for improving and transforming healthcare.
The role of microfluidics in this developing environment is crucial, thanks to outstanding properties such as good repeatability, precise controllability, and a high degree of customisation. The intrinsic versatility of microfluidics makes it perfect for developing *ad hoc* solutions in a variety of biological applications.
This thesis has been envisioned in this context with a clear goal to develop microfluidic-based solutions for current relevant biotechnological challenges. We introduce novel methodologies, such as the one detailed in Chapter 2, where the precise flow control of microfluidics enables to measure the drug uptake times in cancer cells with unprecedented temporal resolution.
In Chapter 3, we show how a microfluidics-driven workflow, enables the isolation and cultivation of previously uncultured bacteria from the human gut microbiota.
Furthermore, this work explores the potential for innovative microfluidic

technologies, as demonstrated in Chapter 4. Here, a novel strategy for generating droplets with dynamic control over their volume range is introduced. The integration of this system within a 3D printing platform is further analyzed on chapter 5, allowing the manufacture of porous, functionally graded soft hydrogels that are relevant for the advancement of tissue engineering.
In summary, in an era marked by the convergence of microfluidics and personalized medicine, this thesis illuminates the transformational potential of microfluidic technologies, revealing unique approaches and creative solutions very promising for the development of biotechnology and healthcare.