Standardized, Modular Parallelization Platform for Microfluidic Large-Scale Integration Cell Culturing Chips

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Introduction

Engineering challenges
As an engineer, you may have solutions to challenges such as robustness and high throughput, but don't know how to implement them in a specific biological setting.

Biology challenges
Here we present a modular system with standardized interfacing to parallelize chips with 64 chambers each for high-throughput cell culturing.

Standardized Design

Chip with 64 chambers

Fluidic Platform

Bolts for clamp
Control lines to chip ports
Platform valve control lines
Platform valves forming a chip ON/OFF switch

3 Results

I – Valve characterization

A) Measurement principle: Valve in chip

B) Flow at pumping vs. gating pressures:

One valve (no. 7): 13 valves, \( p_{\text{pump}} = 1.4 \text{ bar} \)

C) Pressure storage in chip control channels:

II – Platform proof of concept

A) Fully assembled platform with 3 chips

B) Individual chip operation:

III – Cell culturing in chambers

A) Chip coating:

- Channels are coated with 100 \( \mu \text{g/mL} \) PLL-g-PEG (poly(L-lysine) poly(ethylene glycol)) to prevent cell adherence.

- Chambers are coated with 0.1 mg/mL collagen-I to promote cell adherence.

B) Endothelial cells after 40 hours:

Brightfield images of chambers 33-48:

Human umbilical vein endothelial cells (HUVECs) were seeded at near confluency and cultured for 40 hours. Fresh medium was flushed through the chambers every 3 hours.

Conclusion & Outlook

Conclusion:
- Parallelization of 3 modular chips on a platform with ON/OFF switch
- 192 independently addressable chambers in total
- Over 2300 valves in the chips are controlled through the platform

Next step:
- Test different concentrations of tumor necrosis factor (TNF-\( \alpha \)) on HUVECs

Outlook:
- Extend library of standardized, modular chips to organs-on-chips field

References


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