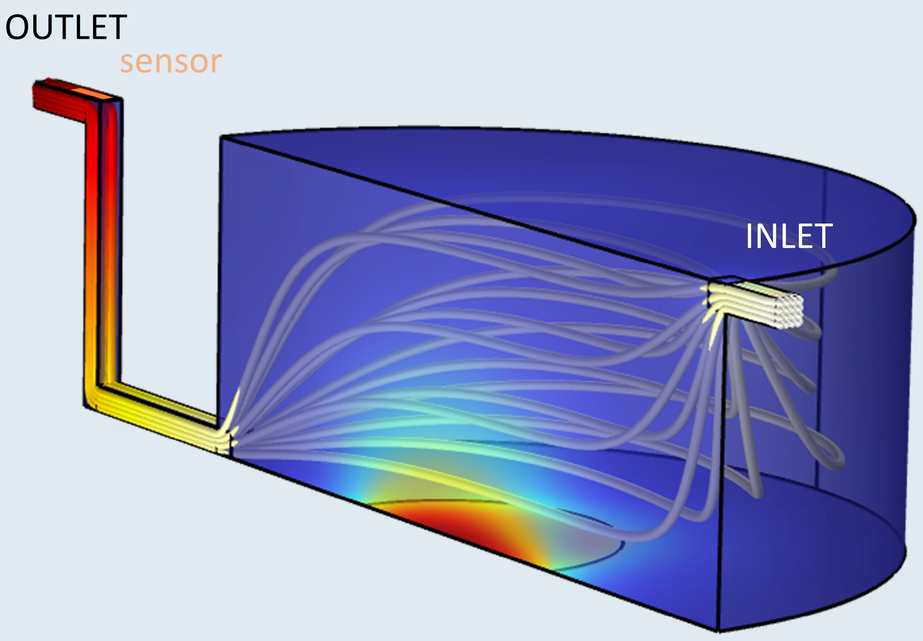

Sensors Integration in Organs-on-Chip

The integration of sensors in organs-on-chip platforms to monitor cellular processes is challenging. Flow conditions and geometries must be optimized to improve detection.

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Abstract

Organs-on-Chips (OoCs) are microfluidics-based systems that support complex cell cultures systems in controllable physiological conditions[1]. Such systems are expected to reduce animal testing and accelerate drug discovery[2]. OoCs can be interfaced with biosensors for real-time and high-throughput measurements. However, such an integration is challenging. Biosensors can rarely operate continuously without degradation of performance whereas OoC operation can last several days or weeks. In addition, changes in molecular concentrations in OoCs can be extremely low.

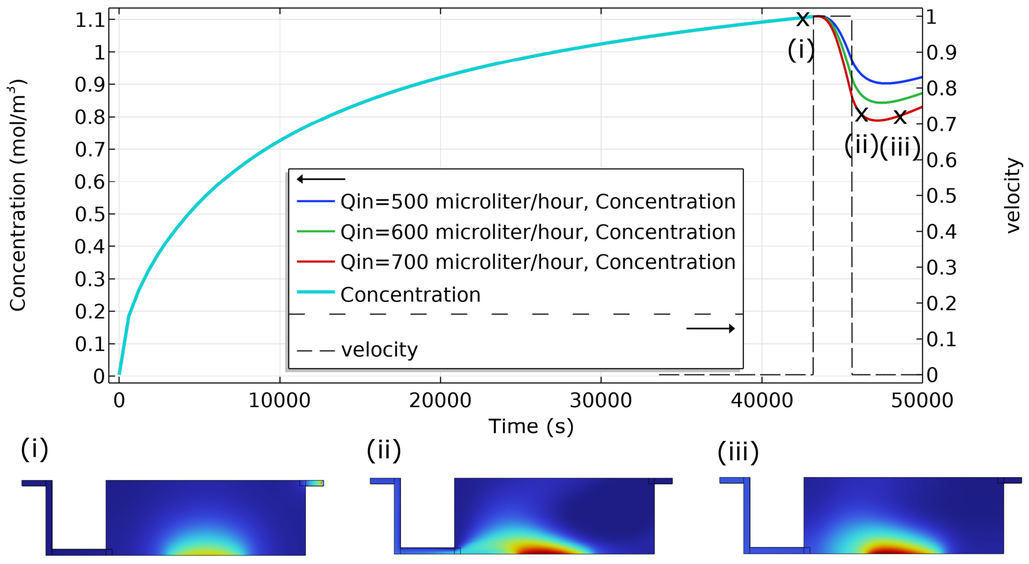

Figure 1. Concentration in the chamber as a function of time and flow rates with evolution of the concentration profile in the chamber at different times.

Methodology

To optimise the flow conditions and dimensions of the platform, we use the Laminar Flow, Transport of Diluted Species and General Form Boundary PDE physics interfaces. The 3D symmetric model consists of a two-step study (Figure 1) to account for the incubation (hours timescale) and the active transport (minutes timescale) steps. Active transport is defined by a rectangle function (dashed line). A parametric sweep in the second study enables the evaluation of several flow and molecular conditions.

Results

Using a first model (not shown), we demonstrated that an incubation time (without flow) was necessary to accumulate enough molecular concentration changes in the chamber to reach the limit of detection of the sensor.

The flow conditions (delay, flow rate and duration) were systematically studied to optimise the transfer of lactate to the sensors. Figure 2 shows that high flow rates may result in excessive dilution.

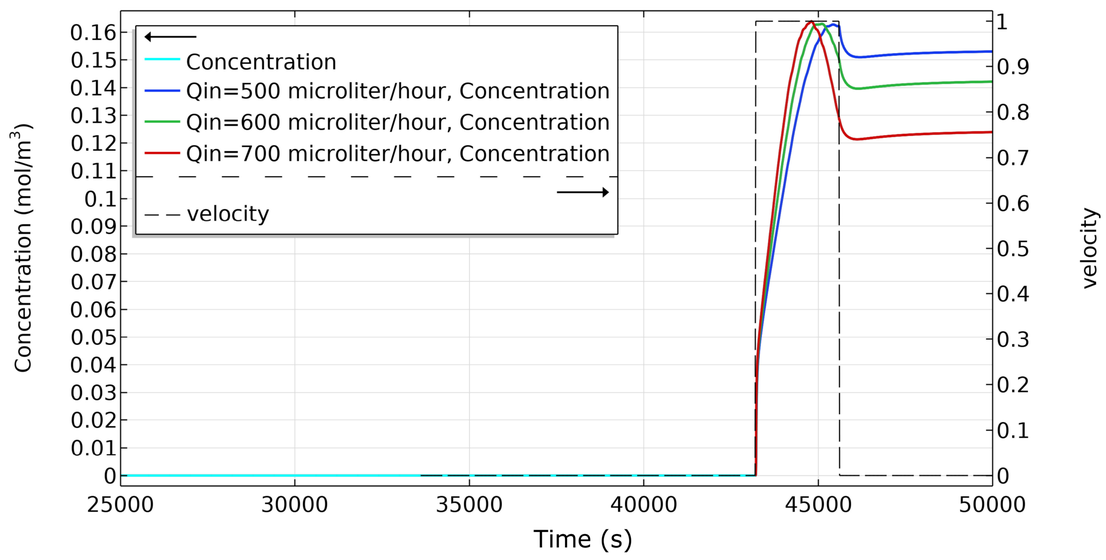

Figure 2. Concentration at the sensor area for different flow rates (500 µL/h, 600 µL/h and 700 µL/h) after 12 hours of incubation and 40 minutes of active transport.

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[2] Loewa, A.; Feng, J. J.; Hedtrich, S. Human Disease Models in Drug Development. Nat. Rev. Bioeng. 2023, 1 (8), 545–559.

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