Simulation of Serpentine Microfluidic Channel for Portable Virus Detection System

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Abstract

This paper presents a comprehensive simulation study of a 3D-printed microfluidic system designed for virus detection using Loop-Mediated Isothermal Amplification (LAMP) at a constant temperature of 65°C for a duration of 35 minutes. To enhance portability and reduce the dependency on bulky thermal cycling equipment required in conventional PCR methods, a serpentine microchannel geometry was designed using AutoCAD and analyzed in finite element simulation. The simulation integrates laminar flow and heat transfer physics to evaluate critical parameters including velocity distribution, volume flow rate, pressure drop, Reynolds number, and temperature profile. Results show stable laminar flow with a low Reynolds number (Re = 0.175), minimal secondary flow effects (Dean number = 0.107), and consistent volume flow rates around 262 µL/hr within 35 minutes.

Thermal analysis indicates effective heat transfer with uniform temperature distribution along the channel. These findings validate the model's suitability for isothermal nucleic acid amplification and support its application in low-cost, point-of-care diagnostic devices.The simulated design can be fabricated using 3D-printing technology for a portable virus detection system.

Author keywords

Finite element simulation; Laminar flow; microfluidic; pressure; Reynold number; temperature; velocity; volume flow rate

Indexed keywords

Engineering controlled terms

Computer viruses; Electronics packaging; Isotherms; Microsystems; Reynolds equation; Reynolds number; Serpentine; Solid-state sensors; Thermoanalysis; Velocity distribution; Viruses

Engineering uncontrolled terms

Detection system; Finite elements simulation; Loop mediated isothermal amplifications; Loop-mediated isothermal amplifications; Microfluidics channels; Microfluidics systems; Reynold number; Simulation studies; Virus detection; Volume flow rate

Engineering main heading

Laminar flow; Microfluidics

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