CALIFORNIA STATE SCIENCE FAIR
2016 PROJECT SUMMARY

Name(s)

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Project Number

36570

Project Title

A Lab-on-a-Chip Device Incorporating Novel Micropumps, Microvalves, and an Acoustic Micromixer for Disease Diagnostics

Abstract

Objectives/Goals

Normal RNA analysis requires multiple lab processes and manual handling that is tedious and prone to human error. The goal of this project is to develop an integrated lab-on-chip device that utilizes novel, but simple microvalves, micropumps, and micromixers, to carry out raw sample-to-answer biological analysis for disease diagnostics.

Methods/Materials

Individual microfluidic technologies were developed first: 1) Acoustic micromixing was tested in a plastic chamber consisting of tiny air pockets. The chamber was machined using CNC and attached with a PZT disk, and a function generator was used to create acoustic energy for micromixing. Relationships between design elements and mixing efficiency were studied through several designs 2) A micropump involving water electrolysis was tested using a DC power supply, NACl solution, and paper clips. 3) Simple microvalves were successfully developed to simplify fluid control using candle-wax and resistive heaters. An integrated microfluidic device consisting of the above components was developed and tested on human urine samples for detection of Chlamydia Trachomatis.

Results

The fully-integrated device demonstrated significant advances to current technology. The acoustic micromixing reduced normal mixing times from 6-8 hours to 6-8 seconds. The inexpensive electrochemical micropump generated only H2 gas for liquid pumping. The relationship between pumping rate and DC current was also established. Furthermore, both normally open and closed wax microvalves for fluidic manipulation were successfully demonstrated. The integrated, self-contained device took raw samples and performed cell lysis, RNA capture/separation, RNA isothermal amplification, and real-time RNA detection for Chlamydia Trachomatis analysis. The device produced diagnostic results comparable to those generated from current technologies.

Conclusions/Discussion

An integrated microfluidic device was successfully developed for RNA analysis-based disease diagnostics. This is the first demonstration of lab-on-chip technology for RNA sample preparation and isothermal amplification on a single chip. With successful diagnostic performances testing Chlamydia Trachomatis, the device yields high potential in diagnosing thousands of other RNA-based diseases. RNA analysis can now be transformed from reliance on bulky, expensive lab equipment to a portable, integrated platform that is more accessible and affordable.

Summary Statement

My project is about the development of a lab-on-a-chip microfluidic device that integrates all lab functions for infectious disease diagnostics into a simple, inexpensive, and effective chip for sample-to-answer biological analysis.

Help Received

I designed, tested, and optimized the device design and individual components on my own. Dr. Robin Liu mentored me and gave me advice on improving my research. RD Bio Sciences Inc. gave me access to their lab equipment to conduct research.