AUTOMATED PORTABLE DEVICE FOR ANTIMICROBIAL SUSCEPTIBILITY TEST OF ANTIBIOTIC COMBINATIONS

Kuo-Wei Hsu[1], Wen-Bin Lee[1], Huey-Ling You[2], Mel S. Lee[3], and Gwo-Bin Lee[1, 4, 5*]**

[1] Department of Power Mechanical Engineering, National Tsing Hua University, Hsinchu, Taiwan
[2]Department of Laboratory Medicine, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan
[3]Department of Orthopaedic Surgery, Kaohsiung Chang Gung Memorial Hospital, Kaohsiung, Taiwan
[4]Institute of Biomedical Engineering, National Tsing Hua University, Hsinchu, Taiwan
[5]Institute of Nano Engineering and Microsystems, National Tsing Hua University, Hsinchu, Taiwan
Email: *gwobin@pme.nthu.edu.tw; **mellee@cgmh.org.tw

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Abstract

Bacterial resistance against antimicrobial agents has become a significant issue in modern healthcare. To reduce dosage of broad-spectrum antibiotics, the minimum inhibitory concentration (MIC) of antibiotics should be determined before administration based on a practice commonly referred as antimicrobial susceptibility testing (AST). However, conventional AST methods are relatively time-consuming and labor-intensive in screening various antibiotic combinations. To enable faster turnaround time of AST, automation of the entire process could be crucial. This work therefore reported an automatic microfluidic system which could automate four different antibiotic combinations with serial broth dilutions in parallel.

Introduction

Conventional AST

✗ Time-consuming
✗ Labor-intensive

Automated portable device

✓ Whole procedure of AST for antibiotic combinations could be carried out without human interruption.
✓ Capable of conducting four different antibiotic combinations with serial broth dilutions in parallel.
✓ Realize point-of-care (POC) personal medicine for antibiotic combinations.

Experiment Setup

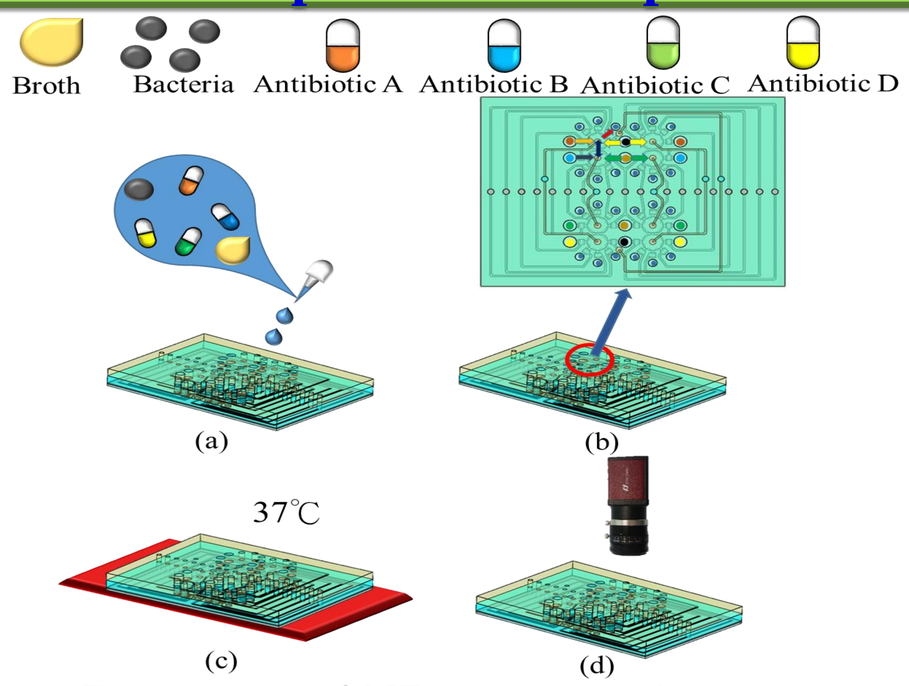

Figure 1: The procedure of AST on an automatic portable system. (a) Load antibiotics and bacteria. (b) Activate AST process on chip by activating a pneumatic control module. (c) Incubate bacteria on a Peltier device with 37°C. (d) Use a CCD camera to detect the AST results.

Chip Design

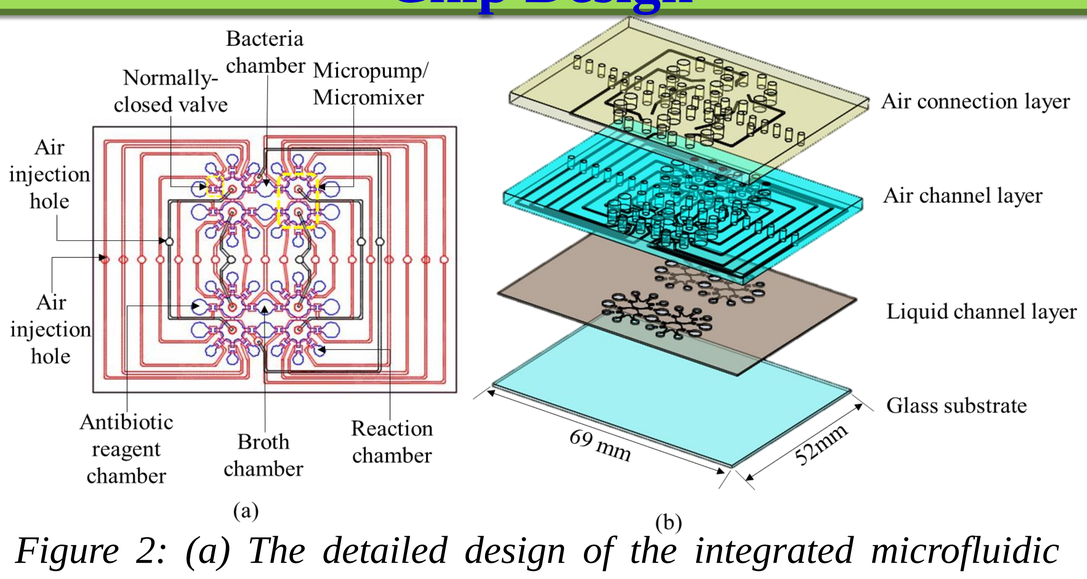

Figure 2: (a) The detailed design of the integrated microfluidic chip. (b) It was consisted of three PDMS layers and a glass substrate. The dimensions of the chip were 69 mm x 52 mm x 6 mm.

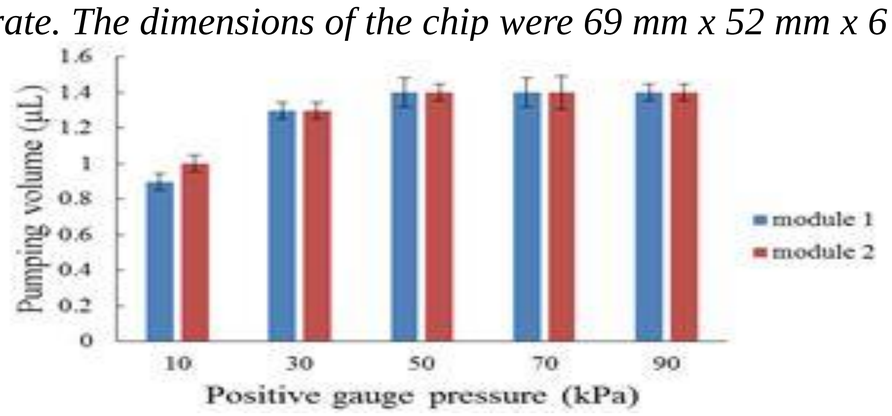

Figure 3: The pumping volumes of the micropumps located in two identical modules. The micropumps of module 1 and module 2 could transport the same volume of liquid to the reaction chambers.

Results

Figure 4: The structure of automated portable device, including flow control, temperature control and image processing modules. Pneumatic control module was controlled by 23 electromagnetic valves. A Peltier device was used for the temperature module to incubate bacteria in reaction chambers. CCD camera was used to monitor the AST results.

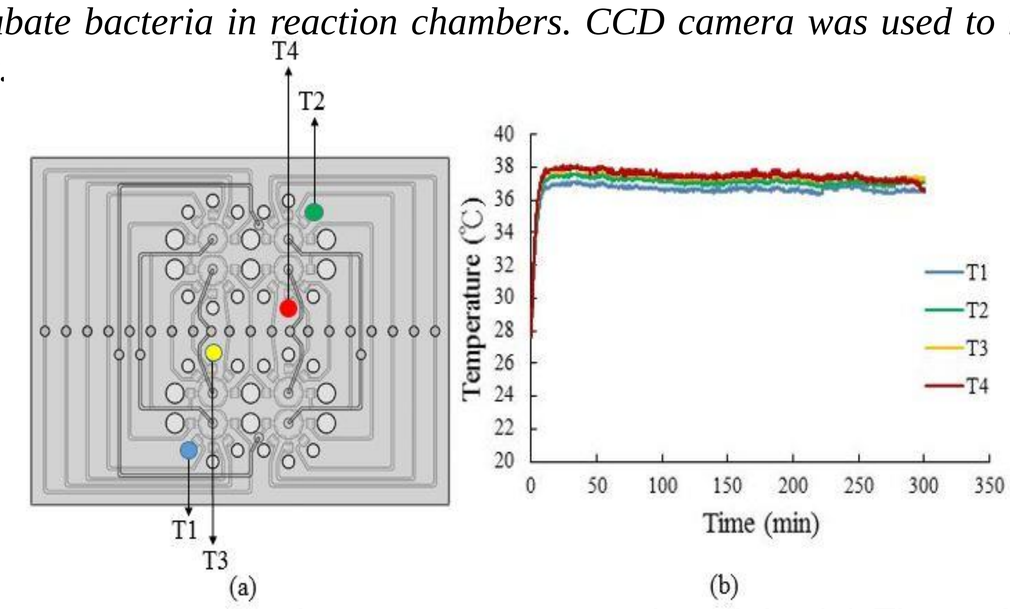

Figure 5: Temperature tests on the temperature control module. (a) The positions of test points on chip. T1 and T2 were located in outer chambers, while T3 and T4 were for inner chambers. (b) The temperature profiles of four test points. T1 = 36.7 ± 0.17°C, T2 = 37.2 ± 0.18°C, T3 = 37.5 ±0.18°C , T4 = 37.5 ±0.2°C. The temperature difference between inner and outer chambers was less than 0.8°C.

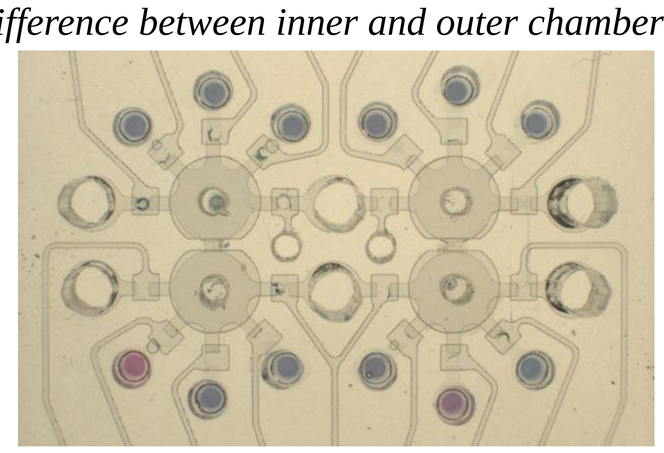

Figure 6: Chip image displayed by CCD camera. Using CCD camera to detect the reaction chamber of the chip and software (imageJ) to perform image analysis.

Conclusions

The automatic portable device containing three main control modules, including a pneumatic control module for microfluidic devices, a temperature control module for maintaining a constant 37°C using a Peltier device to incubate the bacteria in mixed solution, and an imaging module for using a CCD and software (imageJ) to perform image analysis. With this approach, the growth of bacteria could be determined via color change and the MIC values of each antibiotic could be determined accordingly with 5 hours. The developed device could be promising for personal medicine.

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Microfluidic Biochips Lab

國立清華大學 NATIONAL TSING HUA UNIVERSITY