

Assignment Lab-on-a-chip for forensics

Assignment A (BSc): Temperature control of the PCR-reaction – Physics

Introduction:

The number and variety of forensic traces found at a crime scene is enormous. The term forensic science is therefore very broad and can be divided in several expertise areas, such as DNA profiling, blood spatter analysis, explosives and illicit drugs. It is a clear desire of forensic investigators that analyses should be simple, fast, robust, cheap and have high sensitivity and selectivity. Devices with these specifications can be used directly at the crime scene and are especially useful as they can provide immediate information to the police investigators. Most ideal would be a mobile forensic lab for collecting, screening and analysis of the evidence. So-called 'lab-on-a-chip' (LOC) systems can speed up the analysis, are compact, can easily be integrated, limit the risk of contamination and can be used by people who are not technically trained.

However, micro-devices for forensic investigation hardly exist [1]. Experts in LOC technology and/or nanotechnology do not have experience and knowledge about forensic science. On the other hand, forensic experts are in general not familiar with LOC devices. The two disciplines have not yet been combined often in order to obtain an LOC device for forensic research. Combining both disciplines is a goal of this assignment.

Theory:

Several advantages of lab-on-a-chip devices are the fast analysis time, high throughput, minimal amount of analyte material needed, less waste and compactness [2]. Exactly these benefits are the desires of forensic scientists. Other advantages of LOC are limitation of (cross-) contamination, improved chain of custody and possibility of direct analysis at the crime scene, which are the most important issues within forensic science. Obtaining an on-chip DNA-profile is complex as DNA extraction, PCR amplification and STR fragment separation have to be integrated on chip, as can be seen in the figure below [3,4]. Moreover, the 12-72 hour analysis of conventional techniques has to be beaten [4,5]. Fast results are required as a suspect can be held in custody for only 6 hours [5]. For the analysis of human biological samples micro-devices are developed for extraction, purification, amplification, separation and detection.





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One of the aspects of DNA-analysis is the PCR-reaction. To carry out a PCR-reaction with a high yield, good temperature control is of utmost important.

A literature study has to be carried out prior to design chips for forensic DNA-analysis.

- Literature study (~ 2-3 weeks)
 - **Microfluidics:** Get an impression of the possibilities of the use of microfluidics/lab-on-a-chip technology for forensics. Give a short overview of forensic applications (e.g. drug detection, DNA-analysis or fingerprints) of these devices. Which materials (e.g. glass or silicon) can be used for (forensic) chips?
 - **Temperature control for PCR:** Which heating methods (e.g. heater or IR) are applicable on chip? Give an overview of these methods and their advantages and disadvantages. How does the temperature sensing takes place (e.g. thermocouple)? How accurate are these methods?
 - **Temperature management for PCR:** The temperature in a chip can be measured with a sensor, but there are also other possibilities, such as with an indicator. Rhodamine B. is such an indicator[6,7]. Describe how Rhodamine B. can be used for temperature control and also mention other possibilities/alternatives.

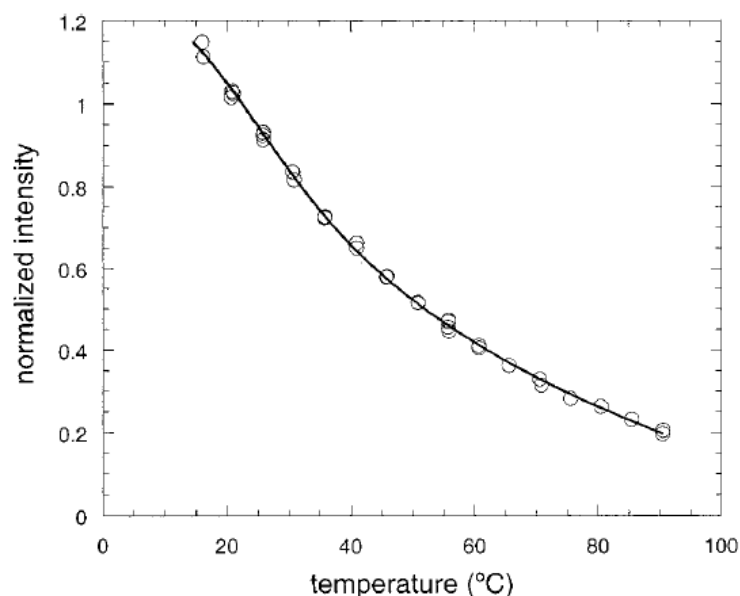
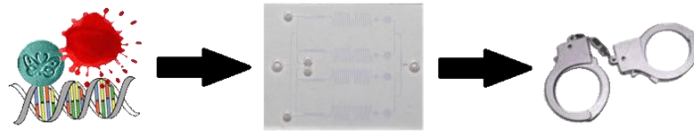


Figure 1. Normalized fluorescence intensity as a function of temperature used to calibrate the fluorescence-based temperature measurement.

From reference number 7



Chip fabrication will be carried out in the cleanroom with micromachining techniques including the set-up development with the microscope and fluidic control.

- Chip experiments and experimental setup (~ 5-6 weeks)
 - **Setup for temperature control:** Design a setup for existing PDMS chip with a fluidic network and external heaters for temperature management and control.
 - **Temperature control for PCR:** Control and measurement of the temperature of various zones of a chip by means of Rhodamine B as indicator.
- Finishing of the report and preparations for the final presentation (~ 1-2 weeks)



References

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