The power of sound: Evaluating the acoustic properties of polystyrene beads and cancer cells

Separation of cancer cells is used in biological research and is an important tool in understanding the disease. Separation of one cell type from another can be obtained by using acoustophoresis - a process that utilizes sound waves in a microfluidic chip. Acoustophoresis has proven to be highly advantageous in the fields of biological research and disease diagnostics. Its benefits include the requirement of only small sample volumes, making it a cost-effective technique. Moreover, acoustophoresis maintains the viability of the cells that are separated. Presently, acoustofluidic devices enable the separation of lymphocytes from granulocytes, as well as the isolation of white blood cells from platelets, among other applications involving the manipulation of small cell samples. To make the separation work, transducers are placed on the channel wall of the microfluidic chip. This will apply an acoustic standing wave field to the main flow channel. Depending on the properties of the cells, such as size, density and compressibility, the cells move in different speeds. The half wavelength resonance applied will make faster cells migrate to the center of the channel and slower will migrate to the sides of the channel. This will lead to separation of particles with different properties. In this thesis, different buffer mediums were used in order to enhance separation between two different cell lines and polystyrene beads. The aim is to gain a deeper knowledge in how the cells behave in the different buffers and if it is possible to separate them from beads. With this knowledge, future research can be made in order to obtain separation between these cell lines and other cells. This in turn would help biological research and disease diagnostics forward. Furthermore, this thesis aims to explore the behaviour for polystyrene beads in varying sizes and in different buffers. Their behaviour is of importance in research, since they are commonly used. To determine how well the separation was, the mobility ratios between the cells and beads were calculated. In other words,the displacement of particles and cells from their initial position in the chip was measured. A higher mobility ratio would indicate better separation.

The thesis utilized polystyrene beads in different sizes that were separated from each other using two different buffers: MQ water and 20\% Iodixanol. Moreover, two cell lines were used: DU145, a prostate cancer cell line, and MCF7, a breast cancer cell line. These cancer types are among the most common in modern times and were obtained from humans and cultivated in a suitable laboratory setting to obtain an sufficient quantity of cells for experimentation. Three different buffer media were tested for the cells: phosphate-buffered saline (PBS) and two concentrations (10\% and 20\%) of Iodixanol. It was observed that, in general, the separation of DU145 and MCF7 cells was most effective when Iodixanol was added to the buffer medium. Particularly for MCF7, the addition of Iodixanol change the sign of the acoustic contrast factor of the cells, causing them to no longer migrate towards the central outlet, thereby enhancing separation. Another interesting finding appeared from the experiments involving only polystyrene beads, where a higher mobility ratio was achieved in 20\% Iodixanol compared to MQ water. This suggests that the polystyrene beads have distinct material properties despite sharing the same composition. This unexpected outcome should be investigated further.

Throughout the experiments, different challenges were encountered. Fibers were found inside the chip that hindered its proper utilization. Furthermore, changing and tuning the total flow rate became a problem. Attempts were made to clean the chip multiple times to get rid of the fiber, but without satisfactory outcome. As a result, a few experiments had to be run with fibers present in the chip due to the limited availability of cells. However, a test run was also performed using polystyrene beads in the presence of the same fiber to assess the potential impact on the results. Fortunately, the fiber did not affect the outcomes. The issue with flow rate calibration was resolved by adjusting it gradually rather than making sudden changes. Consequently, all experiments took longer than expected, limiting the ability to test as many buffers as initially planned. Furthermore, working with cells proved to be more challenging than expected. One can sometimes forget that they are living creatures and needs to be treated as such.

The conclusion that can be drawn from this thesis is that in general, adding Iodixanol to the buffer gives a better separation for DU145 and MCF7 cells, as well as for polystyrene beads. This knowledge can give a deeper understanding in cancer biology with a future goal to separate these cancer cells from other cell lines. However, further research needs to be done regarding the material properties of the beads. As MCF7 has negative contrast factor when adding Iodixanol up to 20\%, they would be possible to separate from DU145 in that specific buffer. However, it would also be interesting to test this hypothesis since we know that science does not always give the intended outcome.