Novel Materials and Designs for Cell Separation by Acoustofluidics

Popular Scientific Article

Microfluidics is already responsible for most of the paper you print, but it also has a large, and growing, application in the biomedical sciences. The subfield of acoustofluidics has shown potential in diagnosis of sepsis and cancer. I have attempted to investigate possible alternative materials for such acoustofluidic applications to enable the future success and mass deployment of the technology.

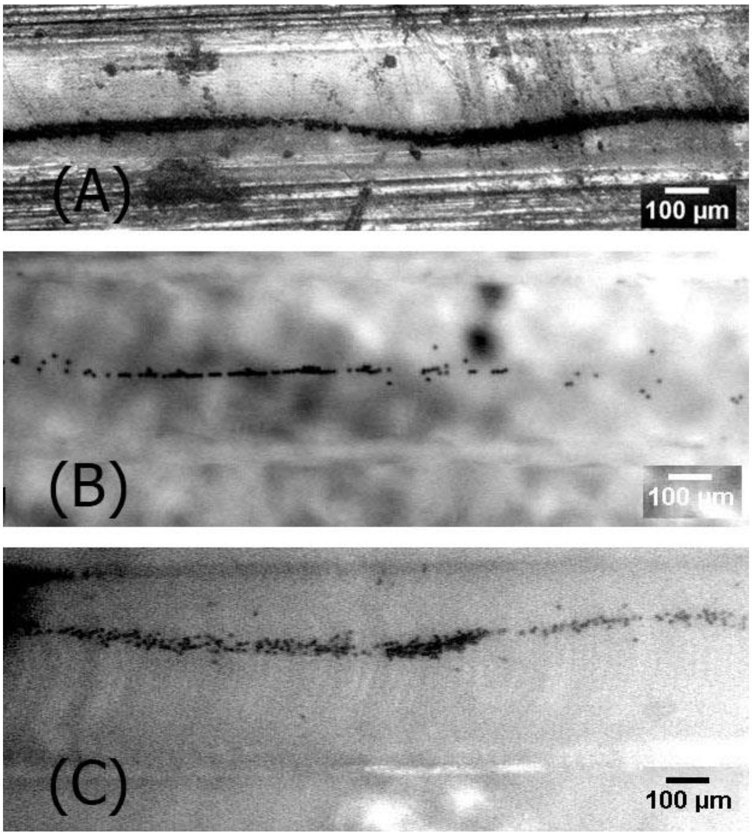
Microfluidics is about handling tiny amounts of fluids. The old way of doing things is to use huge volumes of liquids to accomplish simple things, but more is not always better. When you use very little liquid you are able to know more precisely, and have much more control over, what happens in the liquid. This is in part because of laminar flow, a more predictable flow that arises under special conditions.

Acoustofluidics uses sound waves to manipulate fluids. You can use a small ceramic speaker that sends out sound by exploiting piezoelectricity. Sound is simply pressure differences that travel in a medium. We can hear it when that medium is air and the frequency is in the audible range. The frequency in acoustofluidics is often around 2 megahertz. Sound in a fluid can give rise to acoustic forces acting on particles in that fluid. The size of forces depends partly on the properties of the particles in the fluid. Their size, density, and compressibility all play a part. Acoustofluidics uses these forces to manipulate fluids.

Sound reflects at interfaces of different mediums, and the nature of the reflection depends heavily on the mediums. Since most fluids can be seen as similar to water, the material that makes up the channel is very important. The larger the difference of sound speed and density between mediums, the more of the sound is reflected. Usually, microfluidics has been done in hard materials like silicon and glass, but they are expensive and difficult to work with. Plastic, however, is easily handled, cheap, and there are many different kinds that behave in different ways.

I used three different plastics to make a few simple acoustofluidic chips that were used for testing. The plastics were chosen for their availability and appropriate properties. They were: Cyclic Olefin Polymer (COP), Poly Methyl Methacrylate (PMMA), and Polystyrene (PS). During testing, I applied sound to the devices at the same time as I let tiny microparticles of polystyrene, which simulate cells, flow together with water through the channel.

The acoustic forces focused the particles into a centred line in all three plastics. You can see the focusing in the different plastics in the picture marked A (COP), B (PMMA) and C (PS). The different plastics exhibited varying results, and the robustness and consistency was not perfect, but they all showed successful acoustophoretic focusing. A large part of the success came from the specific design we used for the chips. The design put a pocket of air on either side of the fluid channel. These air holes were placed to let the sound waves reflect off them to strengthen the sound in the channel.



The results of my investigation shows that plastic chips are a viable candidate for acoustofluidic applications instead of the more expensive traditional materials, and that more effort should be expended to create prototypes out of plastic. Hopefully they will be cheap, easy to manufacture, and easy to use.