# Microfluidic blood plasma separation device for Point-of care diagnostics

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**Societal Impact**: Point of care diagnostics has become an inevitable part for health monitoring. It guarantees rapid delivery of results and thus the possibility of making quick decisions, equipped to measure a number of parameters using smaller sample volumes such as CNAs (circulating nucleic acids), proteins, metabolites viruses and bacteria. Blood plasma separation is vital in the field of diagnostics and health care. Due to the inherent advantages obtained at micro-scale, recent trend in these fields is a rapid shift towards miniaturization of complex macro processes. Plasma separation in microdevices is one such process which has received extensive attention of researchers globally. Separating plasma from blood using a microfluidic platform is favored and beneficial in point-of-care diagnostics. Our technology is affordable and can deliver accurate results rapidly. Plasma contains plethora of biomarkers – myriad of analytes, which serve as indicators regarding the functioning of the various systems and subsystems of the body. Biomarkers in blood plasma provide significant information of human health conditions. Most clinical chemistry tests are performed on cell-free blood. Conventionally, the most common method of clinical blood separation is via centrifugation. **The centrifugation process however is both space and time consuming** in terms of the size and amount of equipment needed. Microfluidics allow for small scale point-of-care blood plasma separation using disposable chip systems. These devices may then be able to combine separation with diagnostics in the future to form micro-analysis systems. Relevant information on the health status of a human being will become available more rapidly and at lower cost, and this will ultimately lead to the benefit of the patient. Blood plasma separation microdevices hold great promises of miniaturization and aiding development of point of care technology. Preferably microfluidic analytical systems will eliminate the need for separation techniques that are either costly (centrifugation) or susceptible to malfunction (blockages in filtration techniques) and thereby result in savings in time, energy and costs.

**Specific problem being addressed:** ***Microfluidics allow for small scale point-of-care blood plasma separation*** using disposable chip systems. One can obtain relevant information on the health status of a human being, more rapidly and at lower cost. ***Blood plasma separation microdevices hold great promises of miniaturization and aiding development of point of care technology***. Preferably microfluidic analytical systems will eliminate the need for separation techniques that are either costly (centrifugation) or susceptible to malfunction (blockages in filtration techniques) and thereby result in savings in time, energy and costs. However, separation of plasma from blood using microdevices is not straightforward. This is because the blood components, such as cells and plasma, do not have significant density difference. Also, the cells flowing in the microdevice may form aggregates, thereby clogging the microchannels. Further, the motion of blood cells in microchannel having a non-circular cross section; flow in such non-circular passages is not a well-documented phenomenon. Further, there are certain peculiar characteristics of blood which allows it to behave in several different and unique manners. Not surprisingly, the microfluidic community is still searching for a microdevice which can separate plasma from blood in an efficient and cost-effective way.

Blood plasma can be separated in a microdevice using external forces or by passive techniques. Passive separation methods are preferred since they allow for efficient system integration and are simple in design, whereas active techniques require an external source of energy. Our microfluidic device, which is a passive device, is geared towards innovatively combining bio-physical and geometrical effects for skimming plasma from human blood. These effects are Fahraeus effect, bifurcation law, cell-free region, centrifugal action, and constriction–expansion. In the earlier designs, only one (or few) of these effects were utilized. Our innovation lies in utilizing many of these effects together, towards the final objective of obtaining cell-free plasma from whole blood, with a high yield.

In addition, we plan to employ relatively higher dimensions (of the order of hundred microns) in order to avoid the problem of clogging of microchannels. It is noted that designs in the literature employ dimensions of the order of tens of microns; our experience with these designs in the literature is that these microchannels clog within a few seconds of their operation. Therefore, there is a huge scope to innovate this feature of blood plasma separation device. The microdevice will be designed and fabricated using a bio-compatible material (such as poly-di-methyl siloxane or PDMS). An extensive exercise would be undertaken to design the product with the view to facilitate easier manufacturing.

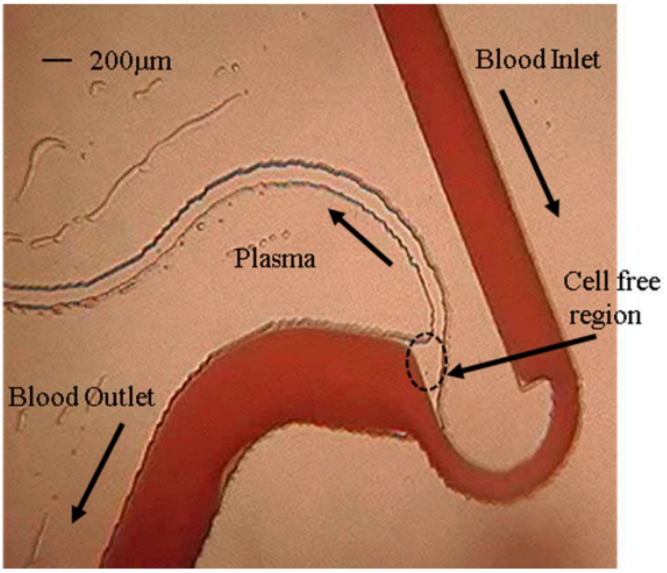


**Figure 1:** Experimental photograph of whole blood design at flow rate of 0.5 ml/min using whole blood.

The project will involve the following steps:

- Designing microchannels, fabrication using photolithography and soft lithography techniques
- Experimentation on available designs to understand and identify important parameters governing the separation process in passive separation techniques (such as feed hematocrit, channel width, flow rate, etc)
- Designing new micro-devices utilizing combination of biophysical effects (Fahraeus effect, bifurcation law, cell-free region, centrifugal action, and constriction–expansion)

- Optimizing the design (for high separation efficiency and high yield) through experimentation

We have already made a significant progress in the development of the technology**. A microdevice exhibiting high plasma separation from undiluted/pure blood has been developed. The innovatively designed and experimentally tested microdevice achieves almost 100% separation efficiency on undiluted blood.** Further, analytes were successfully detected by carrying out biological tests which attests to the high-quality of recovered plasma.