Multiplex Diagnostics on a Spinning Disc

This project aims to develop a portable centrifuge platform for multiple diagnoses using blood samples. The main objective is to develop a portable diagnosis tool for troops especially those deployed in remote resource-limited areas.

Underserved populations living in resource-constrained settings are deprived of any healthcare facilities. Many diseases are endemic in these locations and the troops are inescapable from contracting the infections. It can become life-threatening if not treated and hence proper diagnosis is crucial at an early stage. The proposed work aims at developing a low-cost diagnosis kit for the early detection of diseases including cancer and related complications. The device works on the principle of density-based cell separation similar to the traditional centrifuge systems. A blood sample is placed in microfluidic channels designed on a rotatable compact disc (CD) attached to a motor.

The CDs will be fabricated using poly-methyl-methacrylate (PMMA) sheets. The channels will be engraved in one disc and adhere to two other layers using pressure-sensitive adhesive. The samples will be loaded on the top disc. The discs will be attached to a rotary platform that can revolve at different speeds (RPM) as depicted in Fig. 1.

The device is rotated at an optimal speed (RPM). The targeted blood component, red blood cells (RBC) will be separated in the channels due to centrifugal forces. The device is pre-loaded with deionized water which acts as a lysing agent. It ruptures the captured RBC due to osmosis and releases its components in the channels. For example, for identifying malaria it may be noted that parasites release specific proteins. Antibodies binding to these specific proteins (Histidine-rich protein II (HRP2)) will be loaded in the channels. The antibodies will be labeled using dyes such that it binds to the targeted proteins (if present) and could be visibly detected.

Malaria infections are often associated with anemia. Anaemia is diagnosed as a low count of hemoglobin. The lysis of RBCs in the proposed multiplex device also releases hemoglobin in the channels. The concentration of hemoglobin has been estimated by processing the images which can be captured at the end of the process using a mobile phone. The images have been analyzed using ImageJ software. Furthermore, the accuracy of the tests will be improved by using spectrometers. Spectrometry data are highly accurate for the estimation of hemoglobin concentration which uses the Beer-Lambert principle. We will integrate a portable spectrometer with the mobile phone for the monochromatic light source.

A light source and a mobile phone will be used for capturing the images. The images have been processed using in-house built codes. The results have been validated with data obtained from traditional gold-standard laboratory equipment. In a nutshell, we are going to deliver a diagnostic delivery model where this spinning disc platform has been integrated with an optical or electrochemical sensor as depicted in Fig. 2 enabled by machine learning tools especially random forest and decision trees with niche diagnostics which can easily be deployed to the underserved population in resource-limited settings with the engagement of minimally trained human resources.

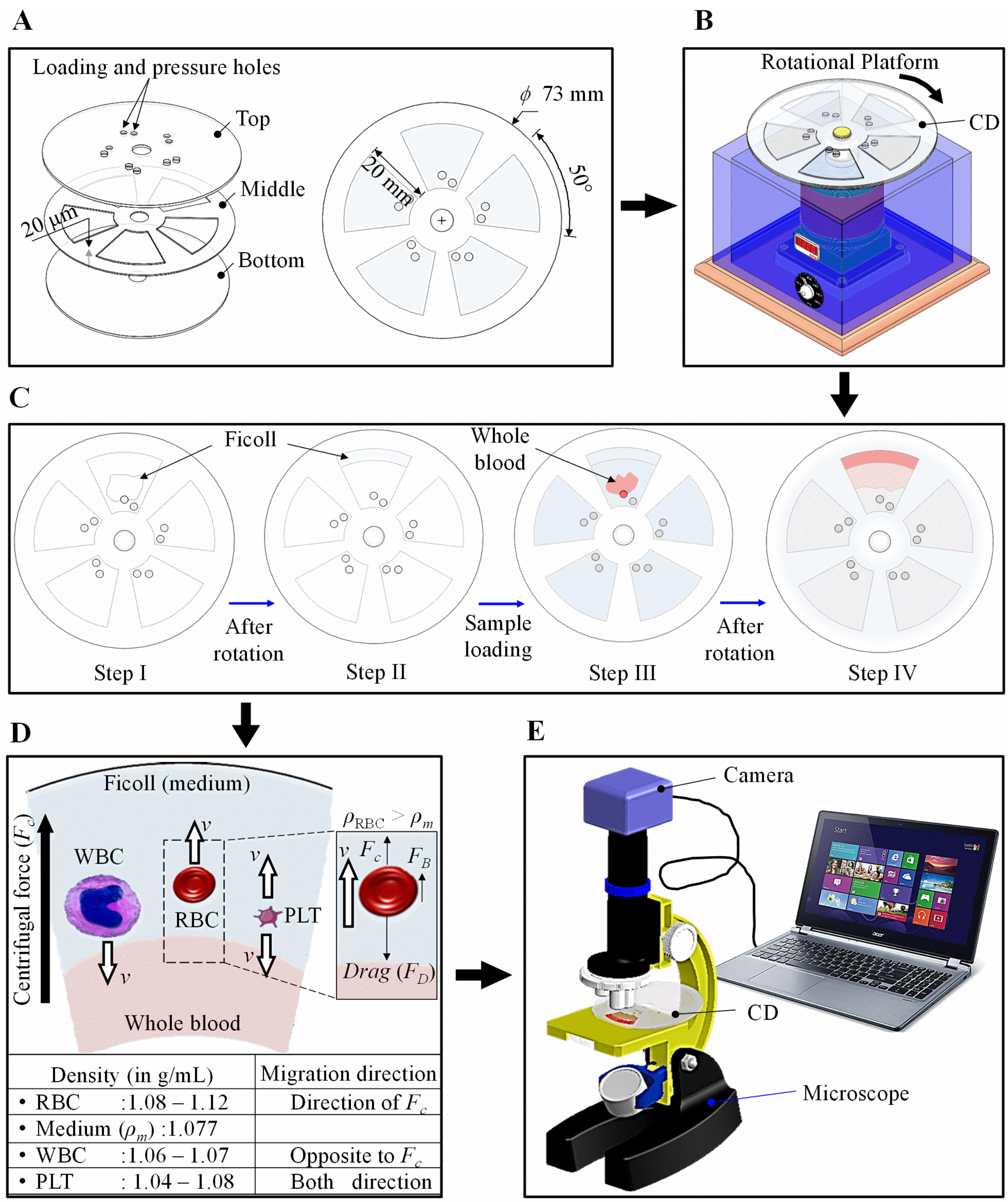

Figure 1 – Pictorial representation of the operational procedure for whole blood cell separation. (A) Design specification of compact disk (CD) based microfluidic channels, (B) Image of rotational platform, (C) Steps for processing the sample in a CD, (D) Illustration of cell migration in the density medium under the action of centrifugal force (F_c). (E) Light microscope for counting the separated cells.

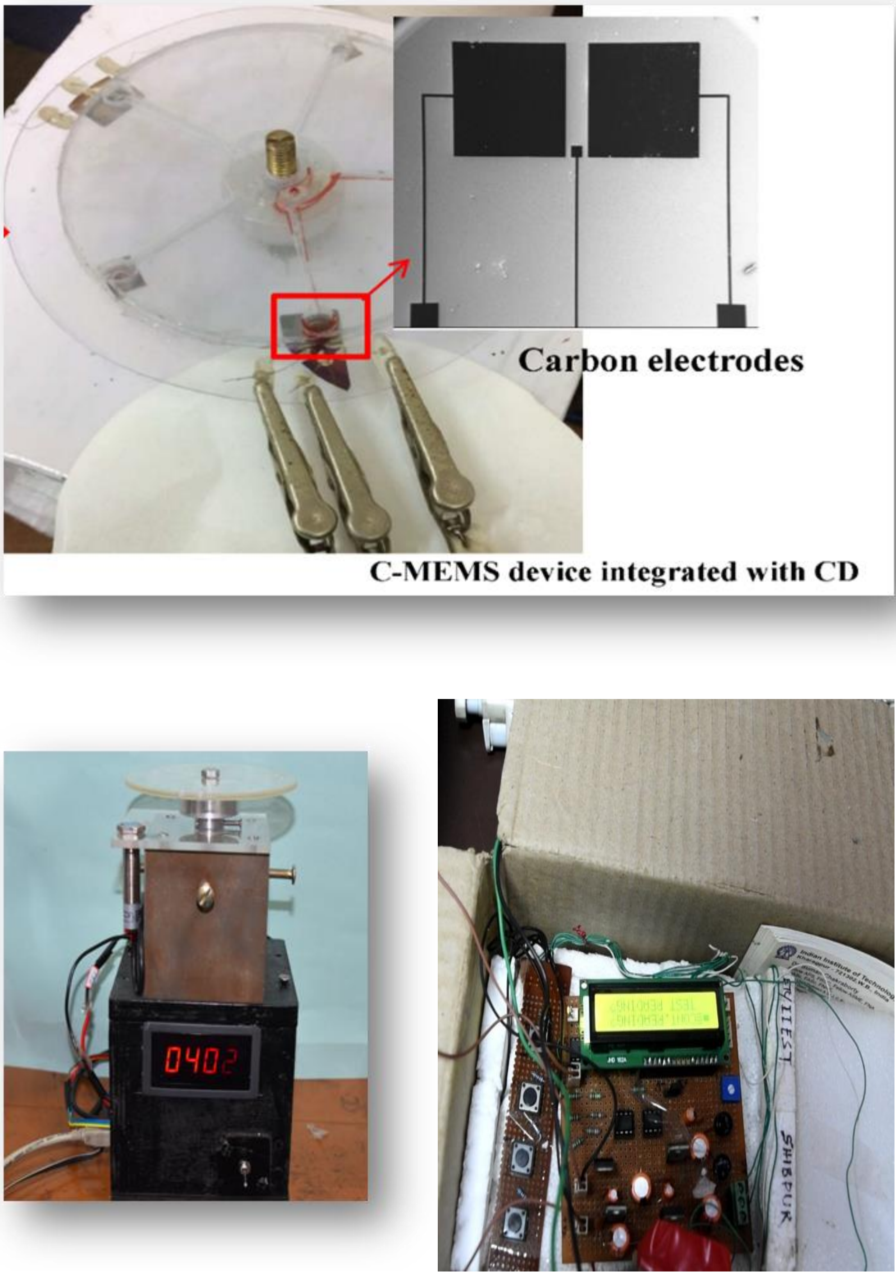

Figure 2 – Electrochemical Sensor Integrated with Portable Spinning Disc