Deformable Microbeads-stacked Nanodevice for Blood Plasma Separation and Blood Cells Retrieval

Xinye Chen[1,2], Shuhuan Zhang[2], Yu Gan[3], Ruoqian Wang[4], Rui Liu[2], and Ke Du[1,2]

[1]*Department of Microsystems Engineering, Rochester Institute of Technology, Rochester, NY 14623*

[2]*Department of Mechanical Engineering, Rochester Institute of Technology, Rochester, NY 14623*

[3]*Department of Electrical and Computer Engineering, University of Alabama, Tuscaloosa, AL 35401, United States*

[4] *Department of Civil and Environmental Engineering, Rutgers, The State University of New Jersey, NJ 08854*

ke.du@rit.edu

Component analysis of blood has becoming one of the most straightforward strategies to accurately monitor human health and diagnose diseases. Blood separation and processing is a vital and essential step in numerous medical and clinical tests. We present here a unique deformable nanodevice (***Fig. 1a***) functionalized by three-dimensional (3D) microbeads for plasma separation and blood cells retrieval. This nanodevice is fabricated by a process demonstrated in our previous publication.[1] Briefly, a shallow channel (2 mm in width, 12 mm in length, and 200 nm in depth) is patterned into a thin layer of silicon dioxide via standard photolithography and buffered oxide etching. In this study, a thin layer of positive photoresist is used as a sacrificial material, which prevents the roof collapse of the Polydimethylsiloxane (PDMS) channel. Two hundred microliters of a suspension of 10 µm microbeads with a concentration of 3.8×10^7 beads/mL are pumped into the nanodevice under a flow rate of 20 µL/min to create a 3D bead-based filtering system (***Fig. 1bi***). Then, 45 µL of the diluted blood sample is pumped into the microbeads-stacked nanodevice for plasma separation. The blood cells captured by microbeads (***Fig. 1bii***) are then easily retrieved by injecting a small volume (e.g., 15 µL) of fresh PBS solution into the nanodevice. Compared to the original sample (***Fig. 3ci***), the filtered sample only contains a few blood cells (***Fig. 3cii***), indicating efficient blood cells removal. In addition, the retrieved sample (***Fig. 3ciii***) shows a similar cell density with the original sample, indicating the efficient red blood cell retrieval. This nanodevice could be used for red cells distribution width (RDW) tests to evaluate the mortality risk among those hospitalized patients infected by infectious diseases, such as SAR-CoV-2.[2]

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[1] Korensky, G., Chen, X., Bao, M., Miller, A., Lapizco-Encinas, B., Park, M. and Du, K., 2020. Single Chlamydomonas reinhardtii cell separation from bacterial cells and auto-fluorescence tracking with a nanosieve device. ELECTROPHORESIS.

[2] Foy, B.H., Carlson, J.C., Reinertsen, E., Valls, R.P.I., Lopez, R.P., Palanques-Tost, E., Mow, C., Westover, M.B., Aguirre, A.D. and Higgins, J.M., 2020. Association of Red Blood Cell Distribution Width With Mortality Risk in Hospitalized Adults With SARS-CoV-2 Infection. JAMA Network Open, 3(9), pp.e2022058-e2022058.

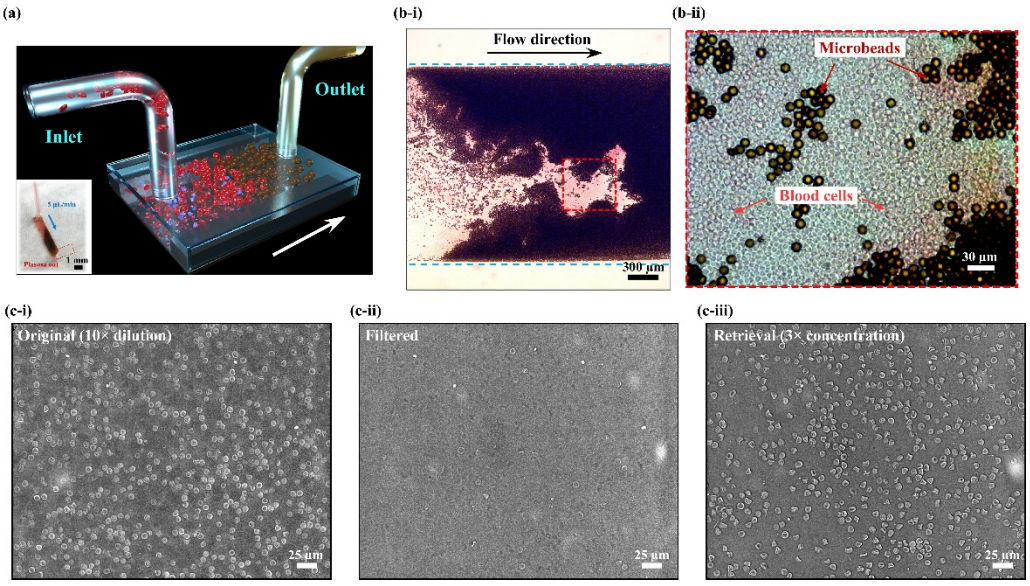

Figure 1*: (a) Schematic of microbeads-stacked nanodevice (the inset image shows practical nanodevice running filtering process); (b) The profile of deposited microbeads with captured blood cells: low magnification (b-i) and high magnification (b-ii); (c) Microscope images of original blood sample (c-i), separated plasma (c-ii), and retrieved blood cells (c-iii).*