Electronic Supplementary Material (ESI) for Lab on a Chip

An on-chip whole blood/plasma separator using hetero-packed beads at the inlet of microchannel

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1. Effect of bead diameter on the velocity of plasma separation

According to Washburn's equation, a penetrating distance (L) of a liquid can be represented [1],

$$L^2 = \frac{\gamma \cdot D \cdot t}{4\eta} \qquad \text{Eq (1)}$$

,where γ is a surface tension, D is a pore diameter, t is a time for the luiquid movement and η is a dynamic viscosity. From this equation, a penetrating velocity (v) of a liquid can be derived as below,

$$v = \frac{\gamma \cdot D}{4\eta \cdot L} \qquad \text{Eq (2)}$$

As shown in Washburn's equation, the velocity of the penetrating liquid through the pores between the packed beads is proportional to the pore diameter (D). In the case of the bead-packed structure, the pore diameter increases with the diameter of the packed beads. As a result, the velocity of blood through the bead-packed region increases with the bead diameter.

By packing the beads inside a microchannel, the velocity of plasma separation according to the bead diameter was experimentally characterized in our previous report [2]. As expected in Eq. (2), the separation velocity increased with the diameter of packed beads. However, if the bead diameter was larger than 20 μm, red blood cells (RBCs) in whole blood could penetrate through the packed beads without the filtration of plasma. In this work, considering this relationship between the bead diameter and the separation velocity, a large bead of 15 μm diameter was adopted to maximize the separation speed while keeping the quality of the filtered plasma.

2. Comparison between bead-packed inlet and bead-packed microchannel

Compared with our previous work in which the beads were packed inside a microchannel [2], the plasma extraction time was greatly reduced and the amount of separated plasma was significantly increased. This enhanced performance of the plasma

separation using the bead-packed structure was attributed to the geometrical shape of the packed beads. When the beads were packed inside the microchannel, the contact area between the blood and the packed beads was approximately the same with the cross-sectional area of the microchannel. In the case of the hetero-packed beads at the microchannel entrance, the dropped blood contacted with a quarter-spherical area of the packed beads, which was much larger than the cross-sectional square area of the bead-packed microchannel. Due to this large contact area with blood, the bead-packed inlet provided a rapid extraction of plasma. Additionally, since the volume of the packed beads in the spherical structure was greater than that of the bead-packed microchannel, large volume of blood experienced the capillary movement through the bead-packed region, which increased the amount of separated plasma.

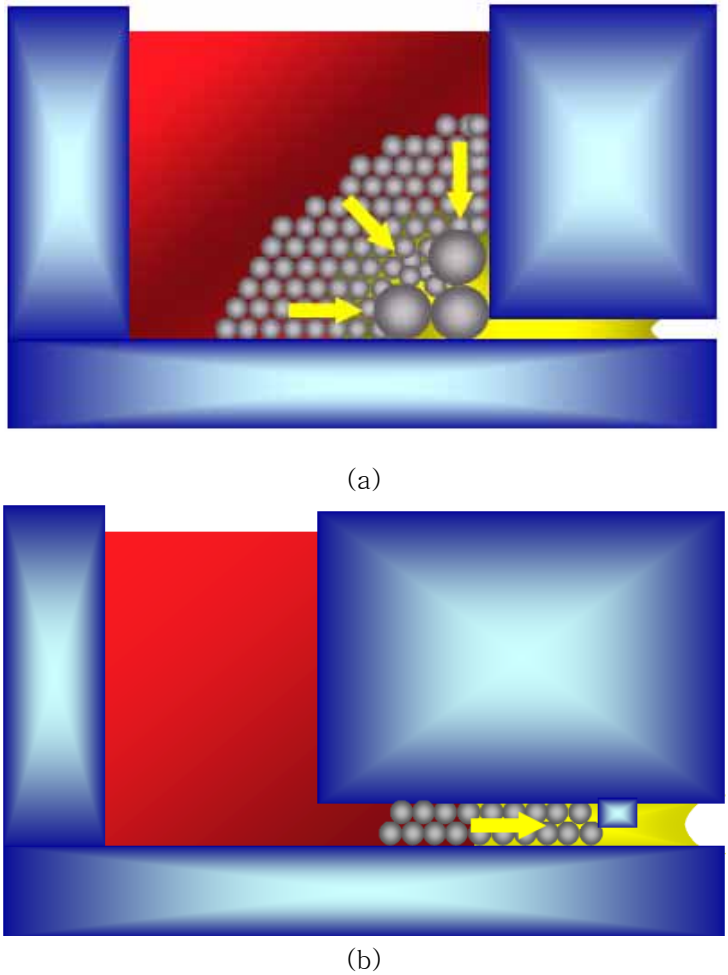
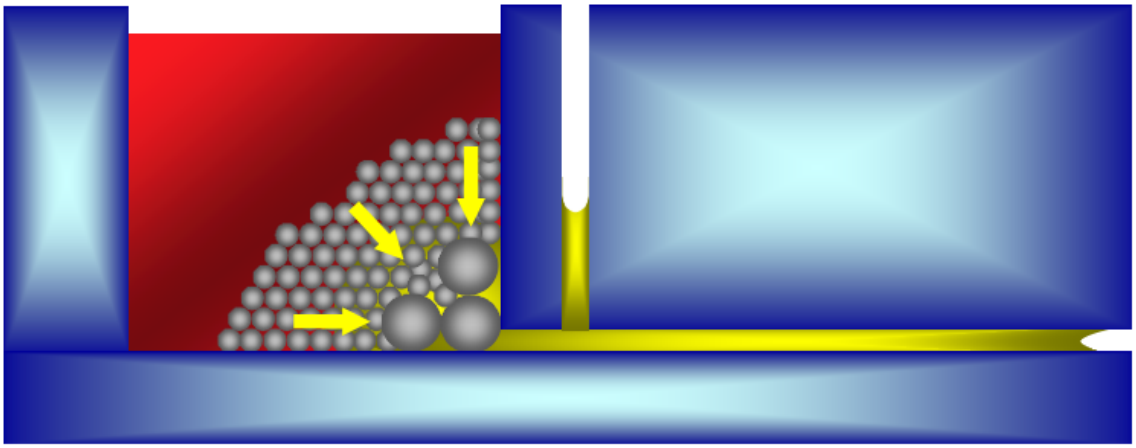


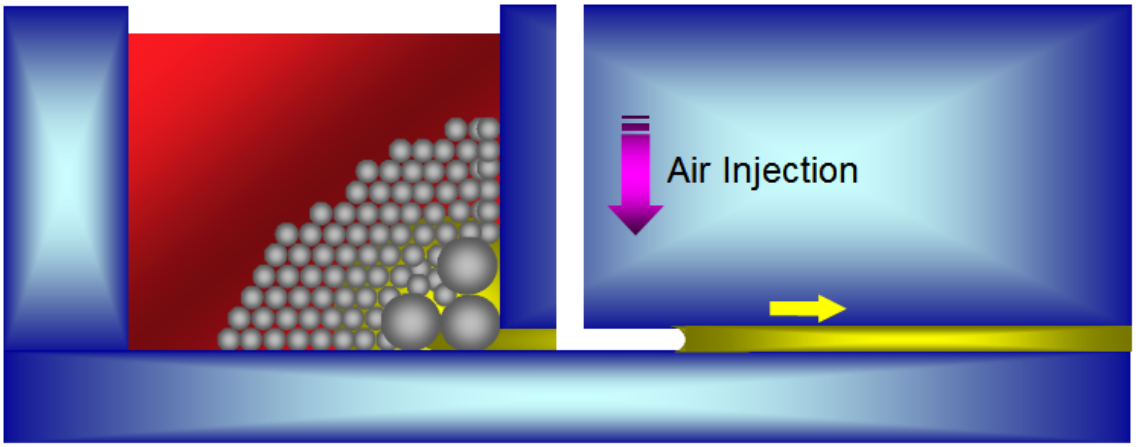
Fig. S1. Comparison of blood/plasma separation between (a) the bead-packed inlet and (b) the bead-packed microchannel. The bead-packed inlet provides larger surface area and bead volume to contact with whole blood. This structural advantage increases the separation velocity and the volume of separated plasma.

3. Delivery of the separated plasma by air injection

In order to actively transfer the separated plasma, one can add the air channel right after the bead-packed inlet of microchannel. The following schematic drawing shows an operation of this device configuration.



(a) Blood/plasma separation



(b) Delivery of the separated plasma by air injection

Figure S2. Schematic design for plasma separation and delivery by air-injection to actively transport the filtered plasma from the bead-packed inlet of microchannel.

Reference

[1] Edward W. Washburn, *Physical Review*, 17 (3), 273, 1921.

[2] J. S. Shim, A. W. Browne and C. H. Ahn, *Biomed. Microdev.*, 2010, 12, 949-957.