Supplementary Information

A Microfluidic Device for Batch Adsorption of Protein on Adsorbent Particles

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Protocol S1 Fabrication of the microfluidic batch adsorption device.

The mask designs were drawn using CleWin software (WieWeb software, Hengelo, The Netherlands) and printed on a 5" soda lime glass by a mask generator LBPG Heidelberg DWL200 (Heidelberg Instruments Mikrotechnik GmbH). Positive photoresist (AZ 40 XT, MicroChem Corp.) was spun onto 4" silicon wafers. The photoresist coated silicon wafers were exposed to UV light through the mask and excess photoresist was developed away to achieve the patterns. For reliable operations of the micro-valves, the cross-sectional shape of channels in the main fluidic layer was rounded by baking the mold at 140 °C for one minute after development. The top fluidic layer was produced by pouring uncured PDMS (GE RTV 615, elastomer: cross-linker = 7:1) onto the mold and the bottom control layer was made by spin-coating uncured PDMS (elastomer: cross-linker = 20:1) onto the master mold. The fluidic and control layers were cured for 45 min and 30 min, respectively, at 80°C. The fluidic layer was peeled off from the mold and holes for inlets and outlets were punched with a 25-gauge punch (Syneo Co., Angleton, TX, USA) and aligned over the control layer using the alignment marks on both layers under a stereomicroscope. The aligned layers were bonded by baking them at 80°C for 60 minutes. The bonded layers were then peeled off from the mold, and holes for control ports were punched. Finally, the multi-layer PDMS device was covered by a pre-cleaned glass slide and kept in the oven at 80°C for 12 hours to enhance adhesion.

Fig. S1 Sequences of mixing valves for the generation of fluid flow in a reactor. A. The design of the device shows 9 reference reactors and 9 adsorption reactors. The control channels (red light color) show the connection of control lines for the operation of three mixing valves. B. Fluid flow generation in a reference reactor and an adsorption reactor with forward sequence (a) and reverse sequence (b). C. Microscope images show the direction of fluid flow with forward sequence (a) and reverse sequence (b).

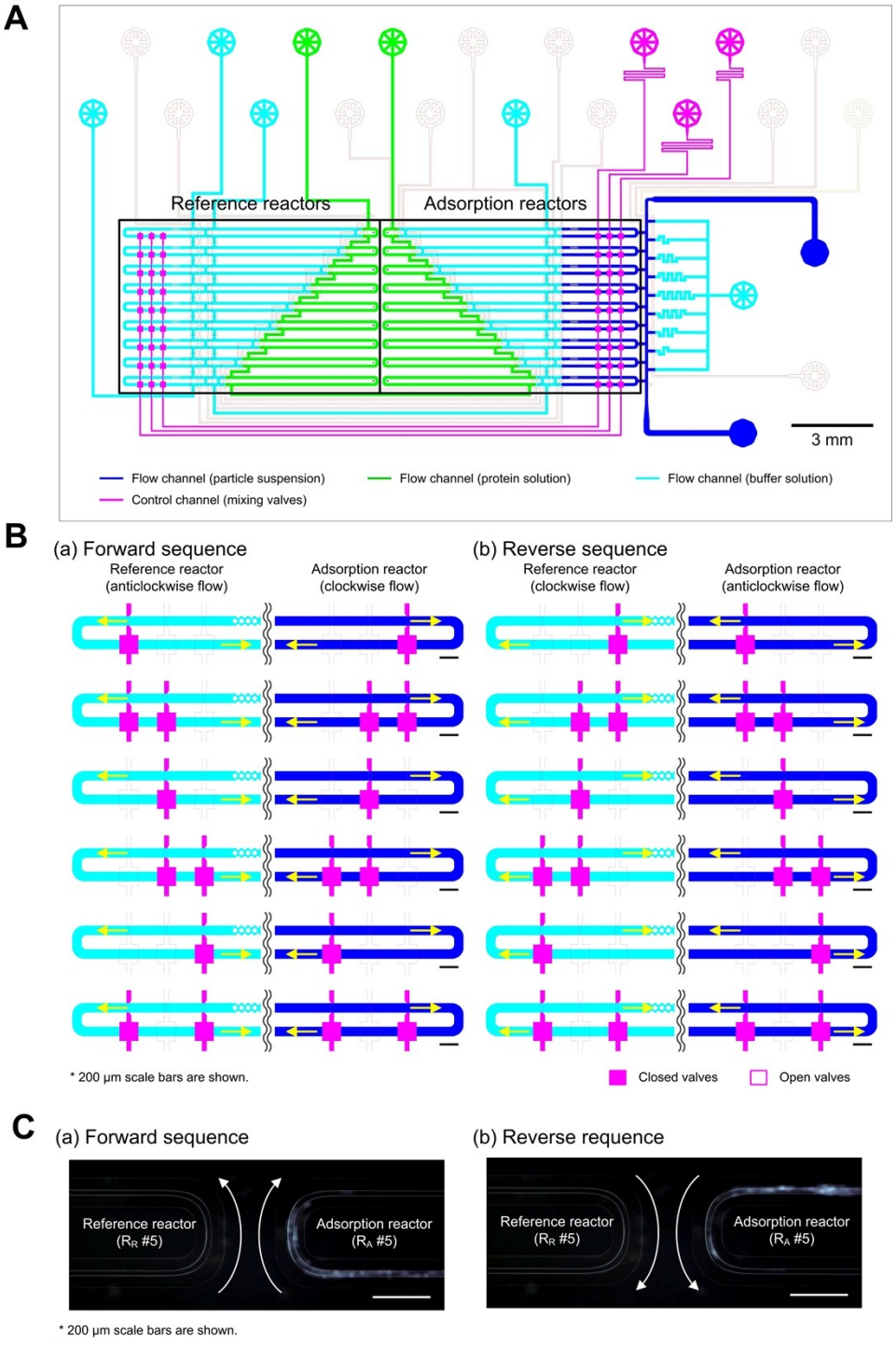

Fig. S2 Design of a microchannel for the measurement of fluorescence intensities of FITC-BSA. The width, length, and height of the channel are 100 μm, 4 mm, and 24 μm (before reflowing), respectively.

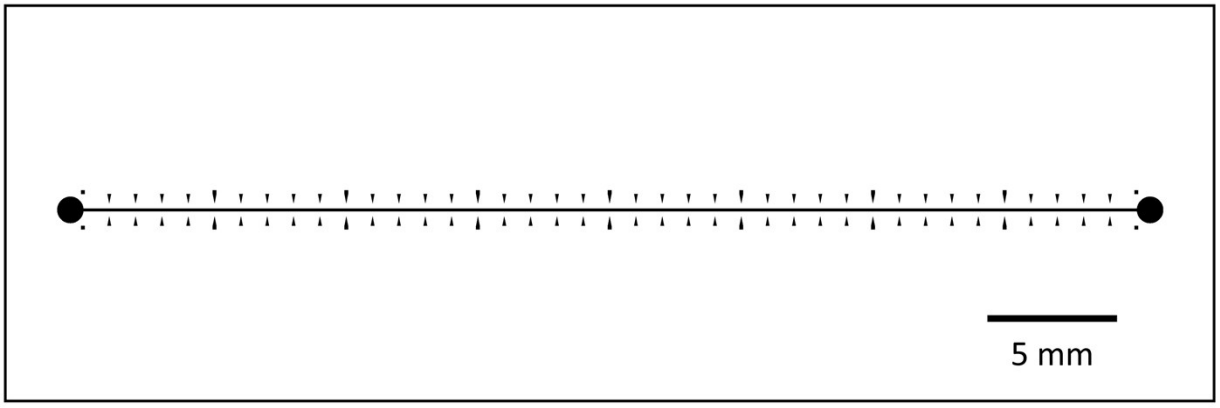

Fig. S3 The volume ratios of three loading sites, a protein site, a buffer site, and a particle site, in 9 parallel reactors in the device. A. The volume ratios of RD solution in 9 reactors by introducing 1 g/L of RD solution and Milli-Q water into the buffer site and the other two sites, respectively. B. The volume ratios of RD solution in the reactors when protein sites were filled with 1.0 g/L RD solution while Milli-Q water was loaded into buffer and particles sites.

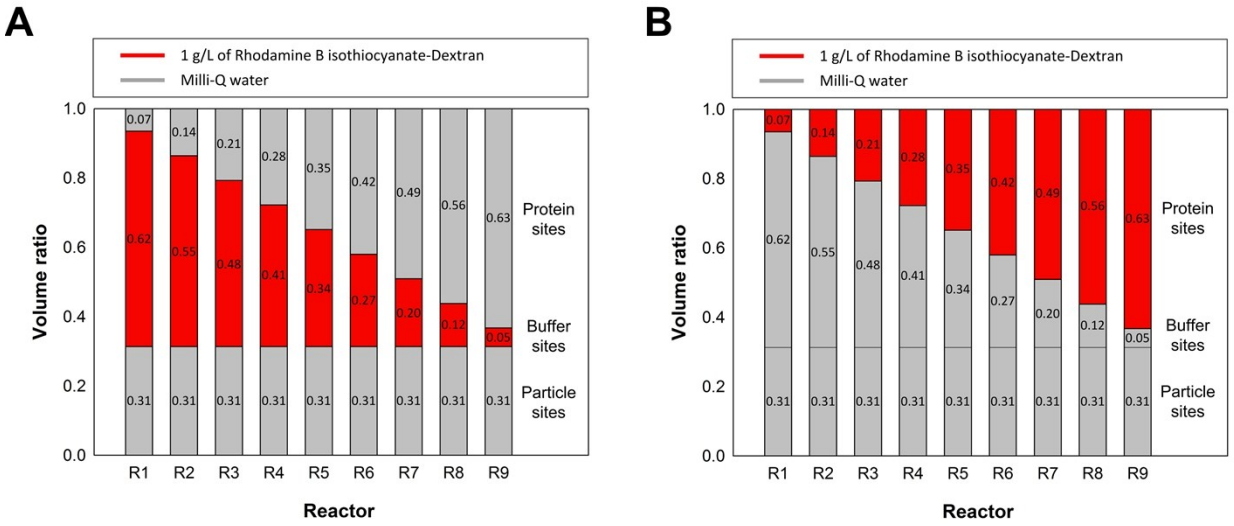

Fig. S3 Adsorption kinetics of FITC-BSA on Source 15Q (S15Q) particles. A. The initial concentrations (C_0) of FITC-BSA in 9 adsorption reactors were varied from 0.39 g/L to 3.80 g/L with an increment of 0.43 g/L. The fluorescence intensities of FITC-BSA in 9 adsorption reactors were monitored every 5 minutes and calibrated to the concentration of the FITC-BSA (C) based on the standard curve. The changes of the concentrations of FITC-BSA (C/C_0) in the reactors were plotted against incubation time. B. The amounts of adsorbed FITC-BSA on an S15Q particle (Q) were calculated and fitted with Langmuir equation. C. The fitted isotherm parameters of FITC-BSA adsorption on S15Q particles, maximum adsorption amount (Q_{max}) and adsorption constant (K_{eq}), were plotted against incubation time.