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Programmed Adsorption and Release of Proteins in a Microfluidic Device

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Microfluidic devices are under development for the preconcentration, separation, sensing, and analysis of proteins from small solution volumes (ultimately the contents of single cells). As system dimensions continue to shrink, interfacial interactions become more and more important in dictating device performance. Research is in progress to develop self-assembled monolayers (SAMS) that can be programmed using "on-chip" stimuli including heat, light, and electric fields to manipulate interfacial interactions including electrical double layer forces, hydrations forces, and hydrophilic/hydrophobic interactions within confined microchannel environments. While several examples of such SAMS will be provided, the focus of this talk will be on thermally-activated thin films of the polymer poly(n-isopropylacrylamide)(PNIPAM) that can be used for the reversible trapping of proteins. At room temperature, measurements obtained using the interfacial force microscope (IFM) show that PNIPAM films swell to generate a repulsive hydration force that inhibits protein adsorption. Above a transition temperature of 35°C, the ordered water within PNIPAM "melts," allowing proteins to come into contact with the substrate and form an adsorbed protein monolayer. PNIPAM films have been integrated into a microhotplate device that allows the adsorption and desorption of proteins to be switched in a controlled fashion. Results obtained using ellipsometry and the quartz crystal microbalance show that the resulting reversible protein trap can be used for protein preconcentrations, crude protein separations, and (in conjunction with antibody trapping) highly selective systems for trapping and releasing specific antigens.