A Novel Detection Scheme Utilizing Nanoparticle Crystals for Rapid and Sensitive Biochemical Sensing

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Recently, nanofluidic structures have been utilized for biochemical sensing. However, traditional nanofabrication techniques are complex, time-consuming, and costly. If the characteristic size of a nanofluidic channel is comparable to or smaller than the Dukhin Length, the ionic conductance will be dominated by the surface charge density. The purpose of this project was to utilize this unique electrokinetic property in nano-meter-sized confined spaces as an electrical read-out biosensor. In our study, nanoparticles are self-assembled in a tunnel-shaped confined space guided by surface microfluidic channels to form a network of nanometer-sized interstices, which have same electrokinetic properties as nanochannels. The surface of the nanoparticles can be modified with various probes. When the target molecule comes into contact with this probe, a change in surface charge occurs. The change in surface charge of the nanoparticles is then quantified by recording the ionic conductance through an electrode pair at the bottom of the packed nanoparticles. The streptavidin-biotin binding reaction, which is one of the strongest non-covalent interactions known in nature, is used to demonstrate the feasibility and sensitivity of this new detection scheme as a preliminary experiment. 540 nm Polystyrene particles modified with streptavidin were used to detect different concentrations of biotin in deionized water. The present results show that these streptavidin-modified nanocrystals were capable of detecting concentrations of biotin as low as 0.8 nM. This lab-on-a-chip detection scheme can be used in both environmental monitoring and medical diagnostic applications for a more simple, rapid, and cheap sensing in the future through probe modifications.