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An ultrasensitive, rapid immuno-detection platform for bacteria and protein biomarkers

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Conventional methods for the detection of bacteria such as ELISA and PCR require a series of culture-based bacteria amplification steps in order to increase the number of the target in the sample to a detectable level. The amplification process makes conventional methods time- and labor-consuming. Detection of protein biomarkers using ELISA is known to provide unsatisfactory sensitivity. Recently, the author has invented Field-Effect Enzymatic Detection (FEED), a novel bio-sensing technique, in which an external gating voltage VG is used to provide intrinsic amplification of the signal current of an enzymatic biosensor by inducing an interfacial electric field to modulate interfacial charge transfer. The quantum mechanics-based technique was used to obtain the detection limit of molecular analytes on the zepto-molar (10^{-21}M) level. The novel method has been elucidated in several publications. The author has incorporated FEED with the immunosensing technique to demonstrate a novel detection platform for biomarkers and bacteria. The detected biomarkers include CA125, PSA in serum and AMACR (a novel marker for prostate cancer) in serum and urine. The PSA and AMACR detections were performed at the femto gram/mL level. The two detected bacteria are *E. coli* and *Shigella. E. coli* was detected in milk and meat juice with detection limits of the order of 10 CFU/mL. Because of the intrinsic amplification provided by FEED, the detection was performed without the culture-based amplification, resulting in a significantly shortened assay time of 1 hr. In these works, FEED provided ultrasensitivity due to its intrinsic amplification whereas the immunosensing technique provided a high degree of substance selectivity. This detection platform sets up a new approach in bio-detection technology, which provides ultra-low detection limit, short assay time and high specificity. It will lead to low-cost detection devices/systems for point-of–care applications. The detection platform will find a range of applications in food safety, public health, environment protection and homeland security.

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Sensing of nanotoxic material using resonance frequency

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Sensing of nanotoxic materials is strongly important, as their engineering applications are growing recently and results in that they can harmfully influence human health and environment. In current study we report the quartz crystal microbalance (QCM)-based, *in situ* and real-time sensing of silver nanotoxic-material by frequency shift. We propose the ultra-sensitive in situ detection of silver ions by using QCM functionalized with a silver-specific DNA. Since the mass of an ion is comparable to that of an atom, the mass change caused by ion binding to DNA on the quartz electrode is so small that it is practically difficult to detect the ions at low concentrations. In our study, we used Ag^+ ions and single cytosine from the DNA to form the cytosine-Ag^{+-}cytosine complex. The advantage of using single cytosine is the mass amplification, facilitating the sensitive detection of Ag^+ ions. The results suggest that QCM-based detection opens a new avenue for the development of a practical water-testing sensor.

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