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Discrimination of Bio-Analytes by Using Two-Dimensional Nano Sensor Array

Authors : P. Behera, K. K. Singh, D. K. Saini, M. De

Abstract : Implementation of 2D materials in the detection of bio analytes is highly advantageous in the field of sensing because of its high surface to volume ratio. We have designed our sensor array with different cationic two-dimensional MoS_2, where surface modification was achieved by cationic thiol ligands with different functionality. Green fluorescent protein (GFP) was chosen as signal transducers for its biocompatibility and anionic nature, which can bind to the cationic MoS_2 surface easily, followed by fluorescence quenching. The addition of bio-analyte to the sensor can decomplex the cationic MoS_2 and GFP conjugates, followed by the regeneration of GFP fluorescence. The fluorescence response pattern belongs to various analytes collected and transformed to linear discriminant analysis (LDA) for classification. At first, 15 different proteins having wide range of molecular weight and isoelectric points were successfully discriminated at 50 nM with detection limit of 1 nM. The sensor system was also executed in biofluids such as serum, where 10 different proteins at 2.5 µM were well separated. After successful discrimination of protein analytes, the sensor array was implemented for bacteria sensing. Six different bacteria were successfully classified at OD = 0.05 with a detection limit corresponding to OD = 0.005. The optimized sensor array was able to classify uropathogens from non-uropathogens in urine medium. Further, the technique was applied for discrimination of bacteria possessing resistance to different types and amounts of drugs. We found out the mechanism of sensing through optical and electrodynamic studies, which indicates the interaction between bacteria with the sensor system was mainly due to electrostatic force of interactions, but the separation of native bacteria from their drug resistant variant was due to Van der Waals forces. There are two ways bacteria can be detected, i.e., through bacterial cells and lysates. The bacterial lysates contain intracellular information and also safe to analysis as it does not contain live cells. Lysates of different drug resistant bacteria were patterned effectively from the native strain. From unknown sample analysis, we found that discrimination of bacterial cells is more sensitive than that of lysates. But the analyst can prefer bacterial lysates over live cells for safer analysis.

Keywords : array-based sensing, drug resistant bacteria, linear discriminant analysis, two-dimensional MoS_2
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