Norani Muti Mohamed[1,2,*]
Veeradasan Perumal[1], Mohamed Shuaib Mohamed Saheed[1, 2]
[1]Centre of Innovative Nanostructures and Nanodevices (COINN),
[2]Department of Fundamental and Applied Sciences, Universiti Teknologi PETRONAS,
32610 Seri Iskandar, Perak Darul Ridzuan, Malaysia.

noranimuti_mohamed@utp.edu.my

Novel 3D Graphene/Au Nanorods hybrids for selective bio-capture: Towards rapid detection of Mycobacterium tuberculosis

The primary objective of this project is to fabricate an ultra-sensitive biosensor from graphene hybrids materials in order to accurately detect the infectious bacteria, Mycobacterium tuberculosis which is the causative agent of tuberculosis, a disease characterised by the growth of tubercles in the lungs and induces high mortality in Malaysia and throughout the globe as described by the World Health Organisation because early stage detection is near impossible as extremely low amounts of the aforementioned bacteria is hard to be cultured and identified using currently available and established methodologies.

At present, many advances have been made to improve the detection of Mycobacterium tuberculosis, however, this effort still falls short of the required efficiency needed to effectively diagnose a patient. The technological gap that exists today is the inability of the immunological assays to detect the bacterial disease when the sample is low. Polymerase chain reaction (PCR) or real-time PCR on the other hand is not a very viable option albeit its high accuracy as the equipment, reagent, sample preparation required are high in cost besides requiring highly trained personnel and contamination free rooms. Similar to PCR, flow cytometry and radiometric detection also requires logistics support form specialised laboratory which makes it unsuitable for developing countries. A commonly used method called cultivation of microbes is also not reliable despite its high accuracy because the bacteria requires one to six weeks to grow on culture plates. Besides that, electrophoresis and hybridisation are commonly used for conditions requiring to differentiate mutant strains from wild strains. Furthermore, methods such as shear microscopy are highly prone to false negative results. Therefore, it is extremely vital to detect Mycobacterium tuberculosis rapidly and accurately to allow for a complete eradication of Mycobacterium tuberculosis at the onset of the infection.

In the past, cost-effective sensors have been sought after for the development of low-cost point-of-care clinical test systems. Graphene has been considered widely as a preferable choice of transducer in biosensors. It is due to its higher surface area to volume ratio (associated with elevated sensitivity). In addition, graphene possesses remarkable properties, such as extraordinary electrical conductivity, optical transparency and unusual mechanical strength which yield stability to the materials for sensor development. In this study, 3-dimensional (3D) graphene which features a microporous foam-like structure with high conductivity and defect-free is used as the biosensing element. 3D graphene grown by chemical vapour deposition (CVD) technique has unique properties where it can be easily tuned in different sizes, scaled and is free-standing as compared to its 2D counterpart which is non-visible or exists in powder form. The structure of 3D graphene will provide a high sensitivity, fast establishment of steady state, a large aspect ratio and a great signal-to-noise ratio. Using sensitive dielectric method, 3D graphene will detect electrical signal directly by the biomolecular interaction. This is through the analysis of resistance and capacitance that occurs at electrode surface layered with graphene. For the biomolecule detection on 3D graphene, sandwich strategy is commonly used because of greater specificity and minimal background signal. In this type of strategy, two probes are necessary to bind two different sites on an antigen. Here, Mycobacterium tuberculosis is sandwiched between antibody and aptamer as capturing and reporting probes, therefore, complement each other to detect Mycobacterium tuberculosis. The developed biosensor will be able to churn out results at a rapid pace so that the patient will be able to receive immediate medical attention in the event of the presence of Mycobacterium tuberculosis as prolonged infection increases the mortality risk. Another advantage of the biosensor is that it is extremely sensitive as well as selective and it can be used repeatedly. The crowning advantage of this biosensor is that it allows the

detection of minute quantities of Mycobacterium tuberculosis that would not have been able to be detected by other means and can be diagnosed easily by medical professionals.

Keywords: 3-Dimensionl graphene, Chemical Vapour Deposition, Tuberculosis, Biosensor