Summary

6. Summary

The recent discovery of the electrically conductive bacterial nanowires from a variety of microbes possess significant physiological, ecological, and biotechnological implications, and is motivated this thesis work on studying bacterial nanowires from one of the gram negative bacteria, *P. aeruginosa*, in order to explore their properties, identify their functions, and investigate for potential electrochemical applications. A number of microbial strategies for electron transfer to extracellular electron acceptors used to apply in environmental biotechnology as well as in bio-energy production. The present study describes the detailed cultivation procedures and the optimal growth conditions (Log and Stationary phase) to induce bacterial nanowires production by *P. aeruginosa*. The aggregated cell and flagella were dispersed by vibromixing the culture with NaCl and sodium dodecyl sulphate (SDS) for 3 min. After this, the cells were separated from the flagella using centrifugation for 30 min. and that could challenge microscopic analysis and electrochemical measurements of bacterial nanowires. Bacterial nanowires range from tens of nanometer to tens of micrometers long, with a lateral dimension of ~16 nm for single, non-bundled nanowires as characterized by a variety of microscopy techniques including AFM and HR-TEM.

Moreover, electrochemical techniques such as CV, LSV and EIS were employed and confirmed that bacterial nanowires were efficient and electrochemical conductors. Hence, bacterial nanowires are proposed to be composed of closely packed conductive proteins that can facilitate long-range transport of electrons along the nanowires. The direct electrical transport measurements were measured along bacterial nanowires using CV, LSV and EIS. With a measured polarization resistivity on the order of 4457 Ω, bacterial nanowires can serve as a viable microbial strategy for efficient extracellular electron transport.

We have prepared homogenously dispersed metal oxide nanoparticles such as CuO, NiO and ZnO without any agglomeration using chemical method in the range of 3 nm. The metal oxide nanoparticles (CuO, NiO and ZnO) were synthesized and characterized using UV-Vis spectrophotometer, FT-IR, XRD, AFM, SEM and HR-TEM. The bacterial nanowires and metal oxide nanoparticles coated bacterial nanowires were successfully fabricated and characterized by various physiochemical and electrochemical methods. HR-TEM shows that the metal oxide incorporated in protein wires affect the bacterial nanowires morphology and increase the surface area of bacterial nanowires. The CV and LSV existence of metal oxide nanoparticles within the coating increases the potential effect of the bacterial nanowires. The EIS relatively decreased the polarization resistance value and increased the capacitance of the metal oxide nanoparticles coated bacterial nanowires electrodes revealed that the metal oxide coated bacterial nanowires exhibited high electrochemical conductivity in comparison to bacterial nanowires electrode. The demonstrated nanocomposite of the metal oxide nanoparticles coated bacterial nanowires system opens the avenue for the future designing of various metal oxide/bacterial nanowires nanocomposites for electrochemical technological applications.

The results of the electrochemical behavior of the nanocomposite of the metal oxide nanoparticles coated bacterial nanowires using EIS method show that the electrochemical conductivity of the metal oxide nanoparticles coated bacterial nanowires were remarkably improved in comparison with that of bacterial nanowires. Besides, the metal oxide coated bacterial nanowires electrode possesses higher capacitance and lower polarization resistance values than that of bacterial nanowires which indicates a significant enhancement of their electrochemical activity. The enhancement of the electrochemical conductivity might have contributed by the coating of metal oxide nanoparticles with bacterial nanoparticles, resulting the improved electrochemical behavior and electrochemical conductive activity. In metal oxide nanoparticles (CuO, NiO and ZnO) coated bacterial nanowires, polarization resistance were found to be 2618, 2270 and 4044 respectively. The CPE-T values are 5.72, 6.26, 8.15, 9.32 and 7.75 μF cm^{-2} for the blank, bacterial nanowire, CuO, NiO and ZnO coated bacterial nanowire nanocomposite thin films. In comparison with the three metal oxide nanoparticles coated bacterial nanowires polarization resistance, the NiO nanoparticles coated bacterial nanowires polarization resistance was low and the CPE-T value was high. The bacterial nanowires sample polarization resistance was inversely proportional to the electrochemical conductivity of the system. Hence, NiO nanoparticles coated bacterial nanowires possess high electrochemical conductivity and potential electrochemical activity. The present study demonstrate the design of nanocomposite, consisting of the metal oxide nanoparticles coated on bacterial nanowires which would offer the way to fabricate other metallic, metal oxide with bacterial nanowire based nanocomposite for the high-performance electrical/electrochemical conductivity and may have possibility to use in biosensors, bioelectronics, microbial fuel cell design and other biotechnological applications.