

Carbon Nanostructures in Biological Sensors for Space and Terrestrial Applications

Jessica E. Koehne, NASA Ames Research Center, Moffett Field, CA

Biosensing devices comprised of carbon nanotubes and nanofibers have been developed for astronaut crew point-of-care. Their inherent nanometer scale, high conductivity, wide potential window, good biocompatibility and well-defined surface chemistry make them ideal candidates as biosensor electrodes. Here, we report two studies using carbon nanotube and carbon nanofiber electrodes for biomedical applications. First, a 3x3 electrode device, with each electrode containing 40,000 carbon nanofiber nanoelectrodes was fabricated on silicon using traditional microfabrication processing. The device was demonstrated as a multiplexed immunosensor for simultaneous, label-free detection of cardiac troponin-I, C-reactive protein and myoglobin. Antibodies specific to cardiac troponin-I, C-reactive protein and myoglobin were covalently bound to the CNF surface and were characterized using electrochemical impedance spectroscopy and differential pulse voltammetry. Each step of the modification process resulted in changes in resistance to charge transfer due to the changes at the electrode surface upon antibody immobilization and binding to the specific cardiac protein. The real-time label free detection of the three cardiac markers from pure components and mixtures was demonstrated with high sensitivity, down to 0.2 ng/mL, and good selectivity. Detection in human blood serum did not present false positives from non-specific protein adsorption. More recently, this detection scheme has been applied to inkjet printed carbon nanotube electrodes on Kapton and paper. Printed devices have several unique advantages including simple and inexpensive fabrication. The results demonstrate that these sensors can serve a miniaturized, low cost device for detection of proteins in complex mixtures making this platform a good candidate for early stage diagnosis of myocardial infarction. Future inkjet printed devices can be fabricated have the added advantage in their suitability to be manufactured in an in-space, microgravity environment.