Multi-walled Carbon Nanotubes as Ion-to-Electron Transducer in All-Solid-State Potassium Ion-Selective Electrodes

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Carbon nanostructured materials in general and carbon nanotubes in particular exhibit remarkable and unique properties that make them promising candidates for a wide range of applications. In the field of sensors, for example, carbon-based materials such as fullerene (C_{60}) [1], three-dimensionally ordered macroporous (3DOM) carbon [2], and single-walled carbon nanotubes (SWCNTs) [3] have been used as solid-contact ion-to-electron transducer for the fabrication of ion-selective electrodes. Our previous study showed that a film based on the conducting polymer poly (3,4-ethylenedioxythiophene) (PEDOT) doped with negatively charged multi-walled carbon nanotubes (MWCNTs) exhibits higher redox capacitance than, for example, PEDOT doped with chloride ions [4]. This high redox capacitance, which is favorable for a solid contact material in all-solid-state ion-selective electrode, was attributed to the presence of carbon nanotubes in the conducting polymer film.

In this work, all-solid-state potassium-selective electrodes (K⁺-ISEs) based on MWCNTs as ion-to-electron transducer, are fabricated and characterized. The MWCNTs was either dissolved in the potassium ion-selective membrane (K-ISM) cocktail, or used as solid contact between the K-ISM and the electronic conductor. The performance of MWCNTs as ion-to-electron transducer is investigated and compared with that of the conjugated polymer poly (3-octylthiophene) (POT). Results from the potentiometric measurements revealed that the MWCNTs- and POT-based electrodes show almost similar sensitivity to K⁺. The MWCNTs-based electrodes, however, showed more reproducible response than the POT-based ones. Increasing the amount of MWCNTs or POT dissolved in the K-ISM cocktail improved the performance of the sensors. The electrochemical impedance spectroscopic measurements revealed that the overall impedance of electrodes based on POT is remarkably higher than that of the electrodes based on MWCNTs. The bulk resistance of the ISM was decreased as a result of doubling the amount of MWCNTs in the membrane.

References: