MS-1-P-5699 Microscopic and spectroscopic techniques as useful tools in the construction of nanobiosensors based on carbon nanotubes

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A biosensor is a device, which converts a biological response between a target analyte and a bioreceptor into an electrical signal. The bioreceptor can be a microorganism, organelle, cell, enzyme, antibody, nucleic acid etc. All these kind of sensors can exploit the advantages from high surface-to-volume-ratio property of nanomaterials. Carbon nanotubes (CNT) present outstanding electrical and chemical properties and could interact with organic and inorganic compounds therefore can be functionalized with supramolecular complex. The morphology and quality of CNT can be determined by the use of transmission (TEM) and scanning (SEM) electron microscopy. Raman and X-ray photoelectronic (XPS) spectroscopy allow identify the type of CNT and verify the chemicals modifications produced on CNT during the functionalization process. These techniques provide useful information about the biosensor construction process like homogeneity of the CNT network or wide of the layer. This project presents the microscopic and spectroscopic characterization of multi-walled CNT simultaneously purified and functionalized through an acid treatment with HNO3-H2SO4 with the objective of make them more reactive trough the formation of acid carboxylic groups on the CNT and then use it as support for amyloglucosidase (AMG) as a probe molecule and check if the enzyme is still active. All CNT were analyse using SEM, TEM, Raman and XPS. Raman spectra allow observe how the acid treatment removes impurities of the CNT (Fig 1). Chemical functionalization with carboxylic groups is evidenced by XPS spectra showing a peak at 288.5 eV characteristic of carboxylic groups and a shoulder at 287 eV possibly associated with peptide bonds (Fig 2). By the TEM micrographs (Fig 3) it is possible to observe the enzyme onto CNT contrasted with uranyl acetate (1%). The results of enzymatic assay prove that the AMG preserve 50 % of its activity compared against native enzyme. The double-layer capacitance, obtained from the current versus potential characteristics at different scan rates (mV/s), was also obtained for the CNT in each step of functionalization and finally the CNT/AMG system was tested in optimal conditions for the AMG catalyze the substrate. The different responses in the electrochemical capacitance and the results of enzymatic kinetics provide evidence of an adequate functionalization of CNT for their use as electrochemical biosensor. Microscopic and spectroscopic techniques prove that are not only useful but necessary tools for biosensors construction.

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Fig. 1: Raman spectra for A) raw carbon CNT and B) purified CNT

Fig. 2: XPS spectra for raw CNT, purified CNT and system CNT-AMG. Inset: zoom in the range 286-291 eV.

Fig. 3: TEM image of a CNT covered with AMG and contrasted with uranyl acetate at 1%