Immobilization of avidin on the functionalized carbon nanotubes

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Abstract

Immobilization of avidin was carried out by functionalizing the multi-wall carbon nanotubes (MWCNTs). Treatment with nitric acid and sulfuric acid mixture (1:3, optimized ratio) leads to the functionalization of nanotubes as observed from Fourier transform infrared absorption spectroscopy (FTIR) measurements. Avidin was coupled with the solution of N-hydroxysuccinimide (NHS) and 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (EDC) and then immobilized on nanotubes. X-ray photoelectron spectroscopic (XPS) studies show a shift in the peak position of C 1s towards lower energy side and changes in the bands with treatment immobilization. The shoulders and shift in photoelectron peak positions indicate the destruction of the graphite structure of the surface layer. SEM images showed that after functionalization, the nanotubes are seen with open ends, granular surface and are joined together. This indicates that after treatment, the CNTs reactivity increased at the ends as well as at the sidewalls. It is believed that the NHS often assist the carbodiimide coupling in the presence of EDC, reacts with the amine function to yield the amide bond. The carbodiimide catalyzes the formation of amide bands between carboxylic acids and amines by activating carboxyl. The reaction of complex containing avidin can form a covalent bond with functionalized carbon nanotubes as observed from FTIR and XPS measurements.

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1. Introduction

There has been intense interest on carbon nanotubes since their discovery by Iijima in 1991 because of their excellent mechanical, electrical and nonlinear optical properties [1]. These properties and their unique structure made them a potential candidate for nanoelectronics, sensors, electrochemical storage of energy, structural composites and high-tech electrical and optical actuator applications. For some of these applications, highly purified carbon nanotubes are necessary. Nevertheless, it is widely reported in the literature that the purification method leads to the structural changes and affect the CNT functionality/properties [2–8]. These structural changes can have important implications for their novelistic applications in addition to the functionalization [9]. The literature review shows that the purification by acid washing creates an open end termini in the structure that are stabilized by −COOH and −OH groups left bonded to the nanotubes at the end termini and/or the sidewall defect sites [10–12]. The −COOH can be coupled to various biochemical groups depending on the choice of the coupling chemicals and/or bio-materials.

Bioelectronics is a rapidly progressing interdisciplinary research field that combines biotechnology, chemistry, micro-electronics, physics and materials science. Avidin is a protein present in raw egg white, which binds biotin. Biotin (Vitamin B-6) is required for cell growth and for the production of fatty acids. Biotin also plays a central role in carbohydrate and protein metabolism and is essential for the proper utilization of the other B-complex vitamins. Avidin, when synthesized in the hen oviduct, is a glycoprotein of MW 68,000 Da which occupies about 0.05% (w/w) of the total protein content of the hen egg white. The ability of avidin to bind biotin (Vitamin H) with