Nitric Acid Treated Multi-Walled Carbon Nanotubes Optimized by Taguchi Method

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Abstract. Electron transfer rate (ETR) of CNTs can be enhanced by increasing the amounts of COOH groups to their wall and opened tips. With the aim to achieve the highest production amount of COOH, Taguchi robust design has been used for the first time to optimize the surface modification of MWCNTs by nitric acid oxidation. Three main oxidation parameters which are concentration of acid, treatment temperature and treatment time have been selected as the control factors that will be optimized. The amounts of COOH produced are measured by using FTIR spectroscopy through the absorbance intensity. From the analysis, we found that acid concentration and treatment time had the most important influence on the production of COOH. Meanwhile, the treatment temperature will only give intermediate effect. The optimum amount of COOH can be achieved with the treatment by 8.0 M concentration of nitric acid at 120 °C for 2 hour.

INTRODUCTION

Since its discovery two decades ago, carbon nanotubes (CNTs) have attracted many researcher attentions from different fields. CNTs have extraordinary thermal conductivity, high mechanical strength and good electrical and electrochemical properties [1-3]. Due to their unique properties, several studies have been done to investigate various applications of CNTs. Their ability to be surface modify has made them suitable to be applied in composites and biosensor applications where a strong interaction between the others molecules is important. Surface modification of CNTs is usually done by adding any types of suitable functional groups onto the CNTs bodies by one of the four functionalization methods which are covalent functionalization (defect and sidewall functionalization), non-covalent functionalization, π-stacking functionalization and endohedral functionalization. Between all of the methods, covalent functionalization is widely been used to surface modify the CNTs due to their covalent bonding which is more stable and stronger [4].

Oxygenated functional group species are often being covalently functionalized onto the CNTs surfaces by acid oxidation process. Hydrochloric acid, nitric acid, mixture of sulfuric acid and nitric acid are the example of acid that is usually been used as the oxidizing agent during the acid oxidation modification process [5-10]. Oxygenated functional group species not only will help to overcome the hydrophobicity problem of as-synthesized CNTs, however, they will also provided faster electron transfer rate and thus increased the conductivity of the CNTs [9,10].

In biosensor application, most of the DNA biosensor that have been reported, have used CNTs which were modified with carboxylic groups (COOH) as the sensing element to immobilized ssDNA probe onto the electrode [11,12]. During the immobilization process, the amine group from the aminated-ssDNA probe will interact with the

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