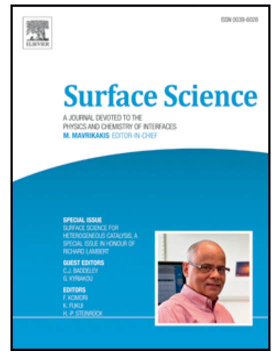

Reaction of folic acid with single-walled carbon nanotubes

Mark D. Ellison, Matthew Chorney

PII: S0039-6028(16)30038-3
DOI: doi: 10.1016/j.susc.2016.03.026
Reference: SUSC 20857

To appear in: *Surface Science*

Received date: 30 November 2015
Revised date: 11 March 2016
Accepted date: 22 March 2016

Reaction of Folic Acid with Single-Walled Carbon Nanotubes

Mark D. Ellison* and Matthew Chorney

Department of Chemistry, Ursinus College

Collegeville, PA 19426

*Corresponding author: mellison@ursinus.edu

Abstract

The oxygen-containing functional groups on oxidized single-walled carbon nanotubes (SWNTs) are used to covalently bond folic acid molecules to the SWNTs. Infrared spectroscopy confirms intact molecular binding to the SWNTs through the formation of an amide bond between a carboxylic acid group on an SWNT and the primary amine group of folic acid. The folic acid-functionalized SWNTs are readily dispersable in water and phosphate-buffered saline, and the dispersions are stable for a period of two weeks or longer. These folic acid-functionalized SWNT offer potential for use as biocompatible SWNTs.

Keywords: carbon nanotubes; folic acid; functionalization; nanomaterials; biocompatibility; infrared spectroscopy

1. Introduction

Although several decades passed between the discovery[1, 2] of single-walled carbon nanotubes and their "rediscovery" by Iijima in 1991,[3] recent years have seen exceptional growth in the studies of their properties and applications. Several favorable properties, including mechanical strength and electrical conductivity,[4] could lead to many useful applications of this material. Additionally, the use of functionalized single-walled carbon nanotubes (SWNTs) is becoming increasingly prevalent in biological applications, such as sensing and drug delivery.[5-13]

Because the electrical conductivity of SWNTs is degraded by surface functionalization,[14-18] pristine SWNTs are valued for the electrical applications. On the other hand, the hydrophobic nature of such SWNTs renders them insoluble in nearly all solvents. For large-scale processing to be feasible, it must be possible to disperse SWNTs in a solvent. Additionally, for many biological applications, electrical conductivity is not a primary concern, whereas dispersability is. Furthermore, toxicity studies of SWNTs indicate that high dispersability leads to a significant decrease in SWNT toxicity *in vitro*.[19-22]

Pristine SWNTs are relatively unreactive, and several approaches to functionalizing them have been developed. For example, Prato and co-workers developed a cycloaddition reaction as a step toward multi-purpose covalent functionalization.[13, 23-26] One of the earliest functionalization strategies arose from the strong acid treatment that was used to purify HiPCO SWNTs.[27, 28] Yates and co-workers were among the first researchers to fully characterize the oxygen-containing functional groups on SWNTs that resulted from such strong acid treatment.[29-31] These functional groups can serve as the basis for covalent linkages with amines[32, 33] and carboxylic acids.[34]

Of particular interest for biological applications are covalent functionalization strategies that yield biocompatible SWNTs whose dispersions in aqueous solutions are stable for significant lengths of time. To achieve this goal, SWNTs have been functionalized with proteins,[5-7, 35] DNA segments,[7, 36-41]