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POLYVINYLPYRROLIDONE WRAPPED SINGLE WALLED CARBON NANOTUBES: SOLID STATE CHARACTERIZATION AND SUPERIOR ANTIMICROBIAL ACTIVITY

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ABSTRACT

Single walled carbon nanotubes (SWNTs) are special in a way that they perform varies physical and chemical characteristics with diverse applications in many fields of scientific research. Despite their outstanding characteristics, SWNTs is challenged by its poor aqueous solubility property due to its super hydrophobicity that becomes a hindrance for their application in many important areas including pharmaceutical life sciences. Previously, the functionalization (*f*-) and non-covalent functionalization (non-covalent-*f*) methods have been explored to increase solubility of SWNTs. However, the *f*- method is said to affect the intrinsic properties of SWNTs while the non-covalent-*f* by polymer wrapping does not. This study shall elucidate the solid state characterization, the probable antimicrobial and antiphysiologic effects of the synthesized polymer polyvinylpyrrolidone wrapped SWNTs (PVP-SWNTs) on bacterial *Escherichia coli* (*E. coli).* First, the characterization of pure SWNTs, PVP and PVP-SWNTs in solid state was determined. These powdered materials were brought to spectral analysis, and thermophysical assay. Results indicated that the solubility of SWNTs in water had increased when aided with PVP wrapping. Results of the spectral analysis revealed that the unprocessed PVP spectra appeared dominantly in the PVP-SWNTs spectral analysis indicating wrapping of PVP over SWNTs. While, the thermophysical study showed formation of endothermic melting peaks of PVP appeared on PVP-SWNTs thermogram which could be interpreted as engagement between PVP and SWNTs. The second part of the study looked at antimicrobial and antiphysiologic activities of dispersed PVP-SWNTs and naked SWNTs on *E. coli*. The conventional antimicrobial study revealed that at 1 mg/ml PVP-SWNTs were able to inhibit the growth of *E. coli* and reduced 95 % of optical density (OD) readings. Finally, increased concentration of PVP-SWNTs and SWNTs showed better antiphysiologic activities towards *E. coli* (maximum concentration is 11.5 v/v % equivalents to 300 µg). The one-way ANOVA showed significant results between groups ($p = 0.002$).

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CHAPTER ONE

INTRODUCTION

1.1 Research Background

Studies on the use of carbon nanotubes (CNTs) in physical and biological environments have been extensively performed. The single walled carbon nanotubes (SWNTs) was reported to have outstanding mechanical (Arash, Wang, & Varadan, 2014; Ruoff, Qian, & Liu, 2003), electrical (Hone et al., 2002), thermal (Hone et al., 2002), optical (De Volder et al., 2013), antimicrobial (Kang et al., 2007) properties and several applications in the field of biomedical sciences such as bioimaging (Chen & Yin, 2014), biosensing (Ma, Ali, Dodoo, & He, 2006), and as vector for drug delivery (Ajima et al., 2005) have undergone tremendous scientific investigations to exploit their unique characters. SWNTs were known to be toxic. That behaviour has contributed to their antimicrobial (Kang et al., 2007; Ajima et al., 2005) and antiseptic properties (Nagarajan, 2012). A recent report gives hope for application of functionalized carbon nanotubes as carrier for antibiotics due to resistant developed by microorganisms towards antibiotics, and enhanced their bioavailability (Dizaj et al., 2015). Based on some other recent reports, functionalized SWNTs with –OH and –COOH groups showed strong antimicrobial activity towards both gram-negative and gram-positive bacterial cells (Arias & Yang, 2009) that affects microorganism cellular membrane integrity, metabolic processes and morphology. The SWNTs microbial activity was buffer, concentration and time dependant.

Despite huge applications of SWNTs in various promising scientific and industrial fields, especially in biological systems including drug delivery, biosensors, biomedical devices and cell biology (Duque et al., 2008), the low aqueous solubility of SWNTs poses a major hindrance for its use in biological research. The poor solubilization restricts their potential as they form bundles and aggregate naturally. These bundled SWNTs have negative impact upon solubilization in organic solvents and water-based systems (Yuan et al., 2008). Solubilization of SWNTs in different types of solvents is very important for different applications. Dispersing SWNTs without the aid of solubilizing agent seems to be impossible due to strong van der