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Transparent conductive film based on carbon nanotubes and PEDOT composites

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Abstract

Single-walled nanotubes (SWNTs), thin multiwalled carbon nanotubes (t-MWNTs) and multiwalled carbon nanotubes (MWNTs) were treated with H_2SO_4–HNO_3 acid solution, under different chemical conditions. The acid-treated CNTs were dispersed in DI water and in poly (3,4-ethylenedioxythiophene) (PEDOT) solution. Furthermore, the finely dispersed CNTs/PEDOT solutions were employed to a simple method of bar coating to obtain the transparent conductive films on the glass and polyethylene terephthalate (PET) film. A sheet resistance of 247 Ω/sq and a transmission of 84.7% were obtained at a concentration of the acid-treated CNTs of 0.01 wt.%.

Keywords: Nanotubes; Electrical properties characterization; Electrical conductivity; Coatings

1. Introduction

Extraordinary electrical, physical and thermal properties of carbon nanotubes (CNTs) make them good candidates for progressing polymer/CNTs composites [1–3]. The improvement of conductivity of transparent conducting film using conducting filler has received considerable amount of attention in the various fields, such as, display technologies, solar cells, flexible electronic devices and optical devices [4]. Furthermore, the traditional transparent conductive films of indium tin oxide (ITO), has a focus of various industries; however, it has several problems, such as flexibility and cost- effectiveness. Nowadays, CNTs have been recognized as one of the most reliable candidates for conductive materials due to its remarkable conductivities [5,6]. There are various methods used for fabricating thin nanotubes film such as filtration [7], airbrushing [8,9], drying from solvent [10], spin coating [11] and Langmuir–Blodgett [12] deposition. However, these methods have a number of limitations in preparing the films, such as film homogeneity and uniformity, efficiency of film production, film thickness controllability and flocculation due to van der Waals interactions between CNTs. In the present work, a novel method of bar coating is used for the fabrication of transparent conductive films of CNTs/PEDOT composites, which is found to be relatively simpler, cost-effective and quick to process over the conventional methods. To apply a wet coating thickness between 4 and 120 μm a wire-wound-bar is used. It is produced by winding precision-drawn steel wire onto a stainless steel rod resulting in a pattern of identical-shaped grooves. The grooves precisely control the film thickness. This method can coat the film homogeneously and the efficiently at large scales and easily control the thickness of film by changing the pitch of coil winding around the bar. The electrical and optical properties of acid-treated CNTs/PEDOT composites were investigated with emphasis on the dispersion of CNTs in the solutions and during forming the film. Raw CNTs have a substantial van der Waals attraction (950 meV/nm), nanotubes tend to aggregate easily and are difficult to suspend in DI water, various solvents and the host resin [13]. Moreover, it is

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