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Nanotechnologies — Characterization of single-wall carbon nanotubes using thermogravimetric analysis

Nanotechnologies — Caractérisation des nanotubes en carbone monofeuillet par analyse thermogravimétrique

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Foreword

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Introduction

Single-wall carbon nanotubes (SWCNTs) are an allotropic form of carbon which exhibit unique mechanical, thermal and electronic properties respective to the geometric structure[1][2][3][4][5]. SWCNTs can be synthesized by several different methods, including pulsed laser vaporization, arc discharge, high pressure disproportionation of carbon monoxide, and chemical vapor deposition[6][7][8]. These processes often yield a heterogeneous mixture of SWCNTs and impurities, requiring post-synthesis purification. Commonly observed impurities include other forms of carbon [e.g. fullerenes, amorphous carbon, graphitic carbon and multiwall carbon nanotubes (MWCNTs)], as well as residual metallic catalyst nanoparticles. Purification can be accomplished using gaseous, chemical and/or thermal oxidation processes[9][10][11][12].

Thermogravimetric analysis (TGA) is one of a number of techniques that can be used to assess impurity levels in as-produced and purified samples containing SWCNTs[14] to [22]. TGA measures changes in mass as a function of temperature and is widely used to assess reaction kinetics associated with structural decomposition, oxidation, corrosion, moisture adsorption/desorption, and gas evolution. By evaluating the reaction kinetics for a given sample, the relative fraction of different constituents present can be either quantitatively or qualitatively determined. For SWCNT-containing samples, TGA is typically used to quantify the level of non-volatile impurities present (e.g. metal catalyst particles). TGA is also used to assess thermal stability (a measure of the type or types of carbon present). However, TGA alone cannot conclusively quantify the relative fractions of carbonaceous products within the material. Therefore, the information obtained from TGA is used to supplement information gathered from other analytical techniques in order to achieve an overall purity and quality assessment of a SWCNT-containing sample.

Additional uses of TGA include process and quality control[23] and the characterization of MWCNTs[24][25][26][27][28] and few-walled carbon nanotubes[29].