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Nanotechnologies — Characterization of carbon nanotube samples using thermogravimetric analysis

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Foreword

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This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

This second edition cancels and replaces the first edition (ISO/TS 11308:2011), which has been technically revised. The main change compared with the previous edition is as follows:

— a generalization has been made from single-walled carbon nanotubes to all forms of carbon nanotubes (including multi-wall).

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Introduction

Carbon nanotubes (CNTs) are allotropic forms of carbon with cylindrical nanostructures. As a result of their geometric structures, these materials exhibit unique mechanical, thermal and electrical properties[1][2][3][4][5]. CNTs are synthesized by several different methods, including pulsed laser vaporization, arc discharge, high pressure disproportionation of carbon monoxide and chemical vapour deposition (CVD)[6][7][8]. These processes typically yield a heterogeneous mixture of CNTs and impurities, often requiring post-synthesis purification. Commonly observed impurities include other forms of carbon [e.g. fullerenes, amorphous carbon, graphitic carbon, single-wall carbon nanotubes (SWCNTs) and multi-wall carbon nanotubes (MWCNTs) outside the desired size or chirality range], as well as residual metallic catalyst nanoparticles. Purification can be accomplished using gaseous, chemical or thermal oxidation processes[9][10][11][12].

Thermogravimetric analysis (TGA) measures changes in the mass of a material as a function of temperature and time, which provides an indication of the reaction kinetics associated with structural decomposition, oxidation, pyrolysis, corrosion, moisture adsorption/desorption and gas evolution. By examining the reaction kinetics for a given sample, the relative fraction of different constituents present can be either quantitatively or qualitatively determined.

TGA is one of a number of analytical techniques that can be used to assess impurity levels in samples containing CNTs[14][15][16][17][18][19][20][21][22]. For CNT-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 of a given sample, providing an indication of the type(s) of carbon materials present. Recent advances in TGA instrumentation enable better resolution during analysis. However, TGA alone is not specific enough to conclusively quantify the relative fractions of carbonaceous products within the material. Therefore, the information obtained from TGA should be used to supplement information gathered from other analytical techniques in order to achieve an overall assessment of the composition of a CNT sample[23][24][25][26][27][28][29].