



BSI Standards Publication

Nanotechnologies — Characterization of multiwall carbon nanotubes — Mesoscopic shape factors

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National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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Nanotechnologies — Characterization of multiwall carbon nanotubes — Mesoscopic shape factors

*Nanotechnologies — Caractérisation des nanotubes en carbone
multicouches — Facteurs de forme mésoscopique*





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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

In other circumstances, particularly when there is an urgent market requirement for such documents, a technical committee may decide to publish other types of document:

- an ISO Publicly Available Specification (ISO/PAS) represents an agreement between technical experts in an ISO working group and is accepted for publication if it is approved by more than 50 % of the members of the parent committee casting a vote;
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An ISO/PAS or ISO/TS is reviewed after three years in order to decide whether it will be confirmed for a further three years, revised to become an International Standard, or withdrawn. If the ISO/PAS or ISO/TS is confirmed, it is reviewed again after a further three years, at which time it must either be transformed into an International Standard or be withdrawn.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO/TS 11888 was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

Introduction

Multiwall carbon nanotubes (MWCNTs) synthesized by chemical vapor deposition (CVD) are of growing interest for use in polymer composites and conductive coatings. In many cases, MWCNTs synthesized by CVD have static (permanent) bend points randomly distributed along their axis. Physical and chemical properties of mass-produced MWCNTs are strongly dependent on the statistical distribution of mesoscopic shapes and sizes of the individual MWCNT (see ISO/TS 80004-3), among other parameters, that comprise the mass produced product (see References [3] to [5]). It is therefore crucial to characterize the mesoscopic shapes of MWCNTs in order to help ensure that the final properties are reproducible for use in a wide range of materials including composites and other dispersions, as well as for Environment, Health and Safety (EHS) issues^[6].

This Technical Specification provides methods for the characterization of mesoscopic shape factors of MWCNTs, including sample preparation procedures. In particular, it provides a statistical method for characterizing MWCNTs produced by the CVD method. During MWCNT synthesis, axial structures are not perfectly linear but include permanent bend points. This Technical Specification provides methods for determining a statistical quantity, representing a maximum straight length that is not deformed by permanent bending called the “static bending persistence length” (SBPL). The SBPL gives information regarding the relationship between the MWCNT mesoscopic shape and size. If two MWCNTs of equal length have different SBPL, their overall sizes (e.g. radius of gyration or an equivalent diameter such as a hydrodynamic diameter) will also be different from one another. In practical applications, the variation in SBPL affects both chemical reactivity and physical properties^{[3][4][5]}.

Electrical conductivity and dimensional stability of MWCNT-polymer compounds are also strongly dependent on the SBPL of the MWCNT used to make them^{[3][4][5]}. Various properties might be affected by SBPL, including electrical percolation threshold^{[5][7]}, toxicity^[6], thermal conductivity^[8], rheological property^[9], and field emission property^[10]. SBPL could be useful for estimating the loading of a polymer CNT matrix to achieve electrical conductivity (percolation limit) and should also assist with modelling the mechanical properties of polymer-CNT composites with different loadings.

Prior to commencing any work, readers are advised to familiarise themselves with the latest guidance on handling and disposal of MWCNTs, particularly in relation to the use of appropriate personal protective equipment. Information on current practices is available in ISO/TR 12885.

Nanotechnologies — Characterization of multiwall carbon nanotubes — Mesoscopic shape factors

1 Scope

This Technical Specification describes methods for the characterization of mesoscopic shape factors of multiwall carbon nanotubes (MWCNTs). Techniques employed include scanning electron microscopy (SEM), transmission electron microscopy (TEM), viscometry, and light scattering analysis.

This Technical Specification also includes additional terms needed to define the characterization of scattered bending persistence length (SBPL). Two approximation methods are given for the evaluation of SBPL (which generally varies from several tens of nanometers to several hundred micrometers).

Well-established concepts and mathematical expressions, analogous to polymer physics, are utilized for the definition of mesoscopic shape factors of MWCNTs.

2 Terms, definitions and abbreviations

2.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Equations for terms and definitions are given in Annex A.

2.1.1

mesoscopic shape

description of shape at the observation scale for an individual multiwall carbon nanotube (MWCNT)

NOTE 1 Mesoscopic shape factors describe the average size and shape of individual MWCNTs, while “macroscopic” describes the shape and size of MWCNT aggregates or agglomerates. “Atomic scale resolution” describes the shape of an MWCNT at the atomic level (see Figure 1).

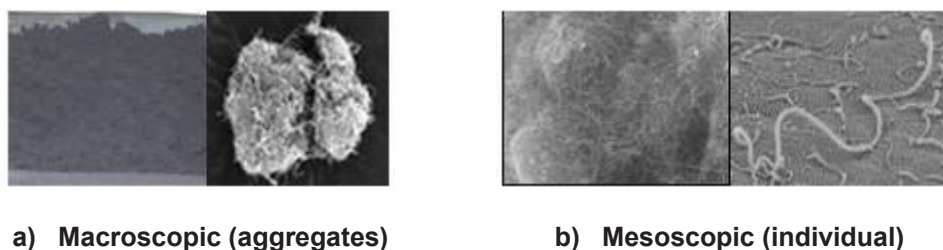


Figure 1 — Shape of MWCNTs at various scales (*continued*)