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Nanomanufacturing – Key control characteristics – Part 6-19: Graphene-based material – Elemental composition: CS analyser, ONH analyser

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NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-19: Graphene-based material – Elemental composition: CS analyser, ONH analyser

FOREWORD

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IEC 62607-6-19 has been prepared by IEC technical committee 113: Nanotechnology for electrotechnical products and systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
113/557/DTS	113/599/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts of the IEC TS 62607 series, published under the general title *Nanomanufacturing – Key control characteristics*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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INTRODUCTION

In recent decades, graphene has attracted extensive attention from academy and industry, because of its extraordinary physical and chemical properties for promising applications in energy storage, electronics, composites, etc. For most graphene powder available either in the laboratory or on the market, apart from carbon, the presence of other elements (e.g. sulfur, oxygen, nitrogen, hydrogen) is inevitable in the course of graphene fabrication. Heteroatoms in graphene can change the material's energy band at different levels, thus affecting its electrical properties and thermal conductivity [1],[2][1]. Therefore, the heteroatom content is a key control characteristic which helps to ascertain the structure and purity of graphene powder, and its determination is significant for the production and application of graphene.

A method used to determine the elemental composition in graphene is the combustion/pyrolysis method, which infers the elemental composition in a sample by analysing the content of the combustion or pyrolysis gases. This method has high analysis efficiency and convenience of operation, but different instruments will provide different levels of measurement uncertainty.

In general, the combustion/pyrolysis method is established on an organic elemental analyser (EA), which uses a thermal conductivity detector (TCD) to analyse the components of the combustion or pyrolysis gases. But for graphene powder, EA is not an excellent tool to access the heteroatom content. One reason for this is that graphene has low density and sputtering happens during combustion. Another reason is that the pyrolysis temperature in EA is set at a relatively low value (e.g. 1 150 °C), which is sufficient for organics but not high enough to completely release oxygen or other atoms in graphene.

The use of a carbon/sulfur analyser (CS analyser) and an oxygen/nitrogen/hydrogen analyser (ONH analyser) can circumvent the above-mentioned problems and provide an efficient and well repeatable method for determining heteroatom content in graphene [3]. The CS analyser quantitatively analyses the combustion gas components using the infrared gas detector (IGD), while the ONH analyser quantitatively analyses the pyrolysis gas components using the TCD and IGD. The instrument has a higher pyrolysis temperature and the measurement of target gases is also completely different.

This document focuses on the determination of chemical composition in graphene powder and standardization of the procedures.

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[1] Numbers in square brackets refer to the Bibliography.

NANOMANUFACTURING – KEY CONTROL CHARACTERISTICS –

Part 6-19: Graphene-based material – Elemental composition: CS analyser, ONH analyser

1 Scope

This part of IEC TS 62607 establishes a standardized method to determine the chemical key control characteristic

- elemental composition

for powder consisting of graphene-based material by

- CS analyser and ONH analyser.

The method as described in this document determines the content of carbon (C), sulfur (S), oxygen (O), nitrogen (N) and hydrogen (H).

The carbon (C) and sulfur (S) content in graphene powder is derived by the content of converted CO, CO_2 and SO_2, which is determined by infrared gas detector (IGD) using a non-dispersive infrared adsorption method in CS analyser.

The content of oxygen (O), nitrogen (N) and hydrogen (H) in graphene powder is derived by ONH analyser using pyrolysis method. The O content is obtained according to the content of converted CO and CO_2, which is determined by IGD using a non-dispersive infrared adsorption method. The N content is obtained according to the content of converted N_2, which is determined by a thermal conductivity detector (TCD) method. The H content is obtained by measuring converted H_2 or H_2O, corresponding to TCD or IGD method.

- The method is applicable for graphene, graphene oxide (GO) and reduced graphene oxide (rGO) in powder form.

2 Normative references

There are no normative references in this document.