

TECHNICAL SPECIFICATION

**Nanomanufacturing - Product specification -
Part 3-6: Graphene-related products – Blank detail specification: graphene oxide
in powders and dispersions**

CONTENTS

FOREWORD	3
INTRODUCTION	5
1 Scope	6
2 Normative references	6
3 Terms and definitions	6
3.1 General terms	6
3.2 General product description and procurement information	9
3.3 Terms related to key control characteristics	10
3.4 Terms related to measurement methods	10
4 General introduction regarding measurement methods	12
5 Recommended graphene oxide specification format	13
5.1 General product description and procurement information	13
5.2 Key control characteristics for graphene oxide powders	14
5.3 Key control characteristics for graphene oxide dispersions	16
6 Overview of test methods	17
Annex A (normative) Key control characteristics and measurement methods	21
A.1 General	21
A.2 Sample preparation	21
A.2.1 Graphene oxide sample in form of powder	21
A.2.2 Graphene oxide sample in form of dispersion	21
A.3 Water content, solid content	21
A.3.1 General	21
A.3.2 Sample preparation	21
A.3.3 Measurement	22
A.3.4 Result report	22
A.4 Apparent density	22
A.4.1 General	22
A.4.2 sample preparation	23
A.4.3 Measurement	23
A.4.4 Result report	23
A.5 Single layer rate	23
A.5.1 General	23
A.5.2 Sample preparation	23
A.5.3 Measurement	23
A.5.4 Result report	23
A.6 UV-vis-NIR absorption	24
A.6.1 General	24
A.6.2 Sample preparation	24
A.6.3 Measurement	24
A.6.4 Test report	24
Bibliography	25

Table 1 – General procurement information.....	13
Table 2 – General material description	14
Table 3 – Key control characteristics for graphene oxide powder.....	15
Table 4 – Key control characteristics for graphene oxide dispersions.....	16
Table 5 – Overview of measurement methods	18

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Nanomanufacturing - Product specification -
Part 3-6: Graphene-related products -
Blank detail specification: graphene oxide in powders and dispersions**

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IEC TS 62565-3-6 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
113/933/DTS	113/950/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/publications.

A list of all parts in the IEC 62565 series, published under the general title *Nanomanufacturing - Material specifications*, 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn, or
- revised.

INTRODUCTION

This document establishes a standardized method to specify graphene-based materials of the type of graphene oxide in form of powder and powders dispersed in liquids. Commercially available graphene oxide differs in multiple ways from the perfect graphene oxide structure as described in the correct academic definition as a monolayer of an oxidized honeycomb arrangement of carbon atoms with a carbon-to-oxygen (C/O) ratio of 2,0.

Typical application areas of graphene oxide are coatings, filters, drug carriers, bio-sensors, and functional fabrics.

A quite common way to synthesise graphene oxide is the processing of graphite in concentrated acid in the presence of an oxidizing agent to exfoliate the graphene layers. Depending on the application, graphene oxide is made available as dry powder and liquid dispersion, e.g. in water. The structure of graphene oxide strongly depends on the method of synthesis. The graphene oxide flakes have various types of small and large defects. Beside the oxygen bound to both sides of the carbon monolayer, it is typically decorated with different types of oxygen containing functional groups.

Subtle differences in the physical structure cause large differences in electrical, optical, and chemical properties of graphene oxide. Therefore, it is important that vendors and users specify the material as precisely as possible. A clear understanding and precise definition of these key control characteristics (KCCs) as well as the availability of standardized measurement methods to measure them is essential to guarantee consistent delivery of materials and intermediate products into industrial processes.

According to the philosophy of the IEC Technical Committee 113 (IEC/TC 113), this is done by the establishment of this document about graphene oxide which lists all technically relevant KCCs of the material in a standardized template.

The referenced measurement standards are taken preferably from the 62607 series because these standards are focused to provide exactly the information from the KCC table. If no 62607 standard exists, other standards can be referenced. As it is mandatory in those cases to provide guidelines for the use of a given standard, these are given in Annex A.

Beside the specified KCCs listed in the BDS, there are always some hidden parameters which are not completely under control. Therefore, general requirements like the method of the production process as well as any kind of post processing (e.g. cleaning) is also part of the document. Vendors and users are invited to add or remove listed KCCs if that is required by the application, and to send their feedback to IEC/TC 113.

In summary, a standardized BDS is essential for the industrialization of graphene technologies and crucial for the continued growth of applications incorporating graphene oxide. As significant differences in both methodology and interpretation of measurement results at the current Technical Readiness Level (TRL) continue to exist from one measurement laboratory to another, it is important that this document as well as the referenced KCC measurement standards of the 62607 series be revised frequently to ensure that the standards represent the state of the art of the technology.

1 Scope

This part of IEC 62565 establishes the blank detail specification for graphene oxide in powders and aqueous dispersions.

This document defines a format for specifying key control characteristics (KCCs), including a list of these characteristics and their corresponding standardized measurement procedures, where available. Numeric values are left blank to be determined between the customer and supplier in the detail specification (DS).

In the DS, key control characteristics can be added or removed by mutual agreement.

If no standardized measurement procedures are available, guidelines in Annex A are presented, which can be used by the involved parties to assure consistent material quality.

For non-aqueous solvents, it is crucial to make modifications to address relevant characteristics such as appearance, pH, and viscosity.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 3954, *Powders for powder metallurgical purposes - Sampling*

ISO/TS 21356-1, *Nanotechnologies - Structural characterization of graphene - Part 1: Graphene from powders and dispersions*

Bibliography

- IEC 60050-112:2010, *International Electrotechnical Vocabulary (IEV) - Part 112: Quantities and units*
- IEC 62607 (all parts), *Nanomanufacturing - Key control characteristics*
- IEC TR 62434, *pH measurements in difficult media - Definitions, standards and procedures*
- IEC TS 62565-1:2023, *Nanomanufacturing - Product specifications - Part 1: Basic concepts*
- ISO 2555, *Plastics - Resins in the liquid state or as emulsions or dispersions - Determination of apparent viscosity using a single cylinder type rotational viscometer method*
- ISO 9277, *Determination of the specific surface area of solids by gas adsorption - BET method*
- ISO 11357-4, *Plastics - Differential scanning calorimetry (DSC) - Part 4: Determination of specific heat capacity*
- ISO 15378:2011, *Primary packaging materials for medicinal products - Particular requirements for the application of ISO 9001:2015, with reference to good manufacturing practice (GMP)*
- ISO 19935-2, *Plastics - Temperature modulated DSC - Part 2: Measurement of specific heat capacity cp*
- ISO 22007-4, *Plastics - Determination of thermal conductivity and thermal diffusivity - Part 4: Light flash method*
- ISO 19606, *Fine ceramics (advanced ceramics, advanced technical ceramics) - Test method for surface roughness of fine ceramic films by atomic force microscopy*
- ISO/TR 13097:2013, *Guidelines for the characterization of dispersion stability*
- ISO/TR 14187:2020, *Surface chemical analysis - Characterization of nanostructured materials*
- ISO/TR 19733:2019, *Nanotechnologies - Matrix of properties and measurement techniques for graphene and related two-dimensional (2D) materials*
- ISO/TS 11308, *Nanotechnologies - Characterization of carbon nanotube samples using thermogravimetric analysis*
- ISO/TS 80004-1:2015, *Nanotechnologies - Vocabulary - Part 1: Core vocabulary*
- ISO/TS 80004-3:2020, *Nanotechnologies - Carbon nanotube suspensions - Specification of characteristics and measurement methods*
- ISO/TS 80004-6:2021, *Nanotechnologies - Vocabulary - Part 6: Nano-object characterization*
- ISO/TS 80004-13:2024, *Nanotechnologies - Vocabulary - Part 13: Graphene and other two-dimensional (2D) materials*
- ISO/PAS 21448:2019, *Road vehicles - Safety and artificial intelligence*
- JCGM 200:2012, *International vocabulary of metrology - Basic and general concepts and associated terms (VIM)*