

# TECHNICAL SPECIFICATION

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**Nanomanufacturing - Key control characteristics -  
Part 4-11: Nano-enabled energy storage - Dispersion stability of nano-carbon  
materials for the electrodes of lithium-ion capacitors: zeta potential method**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**Nanomanufacturing - Key control characteristics -  
Part 4-11: Nano-enabled energy storage - Dispersion stability of  
nano-carbon materials for the electrodes of lithium-ion capacitors:  
zeta potential method**

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

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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](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/publications](http://www.iec.ch/publications).

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## INTRODUCTION

Zeta potential ( $\zeta$ ), a key parameter in colloidal dispersion systems, is defined as the potential difference between the slipping plane and dispersion medium. This potential reflects the interaction between charged particles in suspension and is directly influenced by the distance between the particle surface and the bulk fluid where the mobile phase interacts with the stationary fluid layer.

In industrial contexts,  $\zeta$  serves as a critical measure for determining the stability of colloidal systems. Its utility extends across various sectors, such as pharmaceuticals, wastewater treatment, and food production, where the control of colloidal stability is essential for product performance. High  $\zeta$  values typically indicate strong electrostatic repulsion between particles, minimizing aggregation and ensuring system stability. Conversely, low  $\zeta$  values suggest a dominance of attractive forces, potentially leading to flocculation or coagulation.

Given its broad relevance, the method for measuring  $\zeta$  has become indispensable in ensuring the quality and functionality of colloidal formulations. This document explores the principle of  $\zeta$  and its measurement, while emphasizing its industrial applications and the associated requirements for different sectors.

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## 1 Scope

This part of IEC 62607 specifies the dispersion stability by using the zeta potential ( $\zeta$ ) method for nano-carbon materials for lithium-ion capacitors. This document describes not only the dispersion stability of nano-carbon materials but also the effect of different surfactants as well as the evaluation method for testing long-term dispersion stability using  $\zeta$ . This document describes:

- Dispersion stability of nano-carbon materials using  $\zeta$  for lithium-ion capacitors using carbon nanomaterials as electrodes
- Effect of different surfactants
- Evaluation of long-term dispersion stability using the  $\zeta$  method

## 2 Normative references

There are no normative references in this document.

## 3 Terms and definitions

### 3.1 General related terms

#### 3.1.1

#### **zeta potential**

$\zeta$

potential difference between the slipping plane and dispersion medium

#### 3.1.2

#### **dispersion**

<in chemistry> system in which distributed particles of one material are dispersed in a continuous phase of another material

#### 3.1.3

#### **colloid**

mixture in which one substance consisting of microscopically dispersed insoluble particles is suspended throughout another substance

#### 3.1.4

#### **nano-carbon materials**

#### **carbon nanomaterials**

morphologically confined objects, generally formed in nanometre size either in zero, one, or two dimensions, which are made up of carbon atoms with conjugated  $\pi$ -electron systems at their surfaces

Note 1 to entry: Examples include fullerenes, carbon nanotubes, graphene, graphene oxide, carbon nanofibers, carbon blacks, and carbon onions, etc.

#### 3.1.5

#### **surfactant**

compound that lowers the surface tension (or interfacial tension) between two liquids, between a gas and a liquid, or between a liquid and a solid

#### 3.1.6

#### **electric double-layer**

#### **EDL**

spatial distribution of electric charges that appears on and at the vicinity of the surface of an object when it is placed in contact with a liquid

### 3.1.7

#### **Stern layer**

first (internal) layer that is comprised of a layer of ions charged oppositely to the surface which attach to the surface of the electric double-layer, which forms at a charged surface in an ionic solution

### 3.1.8

#### **slipping plane**

abstract plane in the vicinity of the liquid/solid interface where liquid starts to slide relative to the surface under influence of a shear stress

### 3.1.9

#### **surface charge**

charge on an interface per area due to specific adsorption of ions from the liquid bulk, or due to dissociation of the surface groups

### 3.1.10

#### **stability of colloidal dispersion**

stability which is defined in terms of its ability to contain its chemical and physical configurations, such as composition, formulation, and arrangement, over a period of time or under different physiological conditions (e.g., temperature, light, humidity, polarity, pH, etc.)

## 3.2 Key control characteristics measured according to this document

### 3.2.1

#### **key control characteristic**

material property or intermediate product characteristic which can affect safety or compliance with regulations, fit, function, performance, quality, reliability, and subsequent processing of the final product

Note 1 to entry: The measurement of a key control characteristic is described in a standardized measurement procedure with known accuracy and precision.

Note 2 to entry: It is possible to define more than one measurement method for a key control characteristic if the correlation of the results is well-defined and known.

Note 3 to entry: In ISO TC 16949 the term "special characteristic" is used for a KCC. The term key control characteristic is preferred since it emphasizes the relevance of the parameter for the quality of the final product.

Note 4 to entry: The terms "key performance indicator" or "property" shall not be used to indicate the special meaning of key control characteristics concerning blank detail specification.

### 3.2.2

#### **magnitude and sign of zeta potential**

indications of the colloidal system's stability, with a high potential (positive or negative) providing electrostatic repulsion to prevent aggregation, while a low potential allows attractive forces to dominate, leading to coagulation or flocculation

## 4 Measurement principle and sample preparation method

### 4.1 Measurement principle

The zeta potential ( $\zeta$ ) is the potential difference between the slipping plane and dispersion medium, where the mobile fluid is separated from the one that remains attached to the surface of colloidal particles, as shown in Figure 1.