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Standard**

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**Methods for zeta potential
determination — Streaming
potential and streaming current
methods for porous materials**

*Méthodes pour la détermination du potentiel zêta — Méthodes
de potentiel d'écoulement/courant d'écoulement pour les
matériaux poreux*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO document should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 24, *Particle characterization including sieving*, Subcommittee SC 4, *Particle characterization*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

There are several different types of porous materials, such as porous monoliths, porous particles, deposits of solid particles, etc. Each of these different types can require a special sample handling system. This document covers only those aspects of the measurement and interpretation of electrokinetic and electroacoustic phenomena that are common for all these types of porous materials.

The determination of the zeta potential in wetted porous materials is complicated by the fact that this parameter is not a directly measurable quantity. It is calculated from the measured electric signal (either current or potential) that is generated in the wetted porous material by the liquid moving under the influence of an applied pressure gradient. The theories used in the calculation will not be discussed in detail.

There are a number of situations where electrokinetic and electroacoustic measurements, without further interpretation, provide extremely useful and unequivocal information for technological purposes. The most important of these situations are:

- a) identification of the isoelectric point by titration of the zeta potential against a potential determining ion (e.g. pH titration);
- b) identification of the isoelectric point by titration with other reagents such as surfactants or polyelectrolytes;
- c) identification of a saturation plateau in the adsorption indicating optimum dosage for a dispersing agent;
- d) relative comparison of various porous materials with regard to their electric surface properties.

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Methods for zeta potential determination — Streaming potential and streaming current methods for porous materials

1 Scope

This document specifies methods for the zeta potential determination in porous materials that are saturated with a liquid where the pores are readily accessible. There is no restriction on the value of the zeta potential or on the porosity of the porous material. A pore is assumed to be on the scale of hundreds of micrometres or smaller without any restriction on pore geometry.

This document covers the applications of alternating current (AC) and direct current (DC) methods using aqueous media as wetting liquids.

This document is restricted to linear electrokinetic effects.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1 Terms related to the electric double layer and the zeta potential

3.1.1

Debye length

κ^{-1}

characteristic length of the *electric double layer* (3.1.2) in an electrolyte solution

Note 1 to entry: The Debye length is expressed in metres.

[SOURCE: ISO 13099-1:2012, 2.1.2, modified — In the Note to entry, "nanometres" has been changed to "metres".]

3.1.2

electric double layer

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

3.1.3

electric surface charge density

σ

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

Note 1 to entry: Electric surface charge density is expressed in coulombs per square metre.

[SOURCE: ISO 13099-1:2012, 2.1.6]

3.1.4

electrokinetic charge density

σ_{ek}

effective charges at the slipping plane (shear plane) per area due to partial compensation of the *electric surface charge density* (3.1.3) by the accumulation of oppositely charged solutes in the bulk liquid phase

Note 1 to entry: Electrokinetic charge density is expressed in coulombs per square metre.

3.1.5

isoelectric point

condition of liquid medium, usually the value of pH, that corresponds to zero *zeta-potential* (3.1.7)

[SOURCE: ISO 13099-1:2012, 2.1.10]

3.1.6

surface conductivity

K^σ

excess electrical conduction tangential to a charged surface

Note 1 to entry: Surface conductivity is expressed in siemens.

[SOURCE: ISO 13099-1:2012, 2.2.11]

3.1.7

electrokinetic potential

zeta-potential

ζ -potential

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difference in electric potential between that at the slipping plane and that of the bulk liquid

Note 1 to entry: Electrokinetic potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.1.8]

3.2 Terms related to electrokinetic and electroacoustic phenomena

3.2.1

colloid vibration current

CVI

alternating current generated between two electrodes, placed in a dispersion, if the latter is subjected to an ultrasonic field

[SOURCE: ISO 13099-1:2012, 2.3.1, modified — The admitted term I_{CVI} has been removed; the note has been removed.]

3.2.2

electrokinetic phenomena

phenomena associated with tangential liquid motion adjacent to a charged surface

3.2.3

electroacoustic phenomena

phenomena arising from the coupling between the ultrasound field and electric field in a liquid that contains ions

Note 1 to entry: Either of these fields can be primary driving force. Liquid can be a simple Newtonian liquid or complex heterogeneous dispersion, emulsion or even a porous body. There are several different electroacoustic effects, depending on the nature of the liquid and type of the driving force.

3.2.4

seismoelectric current

SEI

I_{see}

non-isochoric *streaming current* (3.2.5) that arises in a porous body in liquid when an ultrasound wave propagates through

Note 1 to entry: A similar effect can be observed at a non-porous surface, when sound is bounced off at an oblique angle.

Note 2 to entry: Seismoelectric effect is expressed in amperes.

3.2.5

streaming current

I_{str}

current through a porous body in liquid resulting from the motion of the liquid under an applied pressure gradient

Note 1 to entry: Streaming current is expressed in amperes.

[SOURCE: ISO 13099-1:2012, 2.2.8]

3.2.6

streaming current coupling coefficient

$I_{\text{str}}/\Delta P$

electrokinetic phenomenon (3.2.2) determined by the slope of the linear dependence of the measured *streaming current* (3.2.5) on an applied pressure gradient

Note 1 to entry: Streaming current coupling coefficient is expressed in amperes per pascal.

3.2.7

streaming potential

U_{str}

potential difference at zero electric current, caused by the flow of liquid under a pressure gradient through a capillary, plug, diaphragm or membrane

Note 1 to entry: Streaming potentials are created by charge accumulation caused by the flow of countercharges inside capillaries or *pores* (3.3.5).

Note 2 to entry: Streaming potential is expressed in volts.

[SOURCE: ISO 13099-1:2012, 2.2.10]

3.2.8

streaming potential coupling coefficient

$U_{\text{str}}/\Delta P$

electrokinetic phenomenon (3.2.2) determined by the slope of the linear dependence of the measured *streaming potential* (3.2.7) on an applied pressure gradient

Note 1 to entry: Streaming potential coupling coefficient is expressed in volts per pascal.

3.3 Terms related to porous materials

3.3.1

deposit of solid particles

accumulation of individual *particles* (3.3.4) by sedimentation from a *dispersion* (3.3.2) on a solid support

3.3.2

dispersion

multi-phase system in which discontinuities of any state (solid, liquid or gas) are homogeneously distributed in a continuous phase of a different composition or state

Note 1 to entry: This term can also refer to the act or process of producing a dispersion, but in this context the term “dispersion process” shall be used.

Note 2 to entry: If solid *particles* (3.3.4) are dispersed in a liquid, the dispersion is referred to as a suspension. If the dispersion consists of two or more immiscible liquid phases, it is termed an emulsion.

[SOURCE: ISO/TS 22107:2021, 3.7]

3.3.3

monolith

solid porous object with size on scale of a few millimetres or larger

3.3.4

particle

minute piece of matter with defined physical boundaries

Note 1 to entry: A physical boundary can also be described as an interface.

Note 2 to entry: A particle can move as a unit.

[SOURCE: ISO 26824:2013, 1.1, modified — Note 3 to entry has been removed.]

3.3.5

pore

cavity or channel which is deeper than it is wide, otherwise it is part of the material's roughness

[SOURCE: ISO 15901-1:2016, 3.5]

3.3.6

pore size

internal *pore* (3.3.5) width, which is a representative value of various sizes of vacant space inside a *porous material* (3.3.8)

EXAMPLE Diameter of a cylindrical pore or the distance between the opposite walls of a slit.

[SOURCE: ISO 15901-1:2016, 3.13, modified — Part of the definition has been moved to an example.]

3.3.7

porosity

ratio of the volume of the accessible *pores* (3.3.5) and voids to the bulk volume occupied by an amount of the solid

[SOURCE: ISO 15901-1:2016, 3.27]

3.3.8

porous material

materials with cavities or channels which are deeper than they are wide

3.3.9

powder

porous or nonporous solid composed of discrete *particles* (3.3.4) with maximum dimension less than approximately 1 mm

Note 1 to entry: Powders with a particle size below approximately 1 µm are often referred to as fine powders.

[SOURCE: ISO 15901-1:2016, 3.4, modified — Part of the definition has been moved to a Note to entry.]

4 Symbols

a	pore radius
a_i	radius of particles building sediment
c	electrolyte concentration in the bulk
c_i	concentration of the i -th ion species
t_{cr}	time to reach first maximum of the electroacoustic signal
z_i	valence of the i -th ion species
z_{\pm}	valences of cations and anions
D_{eff}	effective diffusion coefficient of the electrolyte
F	Faraday constant
I	ionic strength
I_{see}	streaming current in high frequency AC mode (seismoelectric current)
I_{str}	streaming current in DC mode
K	electric conductivity
K_m	electric conductivity of the dispersion medium or liquid
K_s	electric conductivity of the wetted porous material
P	pressure
R	ideal gas constant
T	absolute temperature
U	voltage
U_{str}	streaming potential
\dot{V}	volume flow rate
ϵ_0	vacuum permittivity
ϵ_m	relative permittivity of the medium
η	dynamic viscosity
φ	volume fraction of solids
φ_{sed}	volume fraction of solids in sediment
κ^{-1}	Debye length
ρ_m	liquid density
ρ_p	particle density