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

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National foreword

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Foreword

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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

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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
ζ
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

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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
$I_{str}/\Delta P$
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
$U_{str}/\Delta P$
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.

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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.

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