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Colloidal systems — Methods for zeta potential determination —

Part 3: Acoustic methods

Systèmes colloïdaux — Méthodes de détermination du potentiel zêta —

Partie 3: Méthodes acoustiques

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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 documents 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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For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: Foreword - Supplementary information

The committee responsible for this document is ISO/TC 24, *Particle characterization including sieving*, Subcommittee SC 4, *Particle characterization*.

ISO 13099 consists of the following parts, under the general title *Colloidal systems — Methods for zeta potential determination*:

— *Part 1: Electroacoustic and electrokinetic phenomena*

— *Part 2: Optical methods*

— *Part 3: Acoustic methods*

Introduction

Zeta potential is a parameter that can be used to predict the long term stability of suspensions and emulsions, and to study surface morphology and surface adsorption of particles and other surfaces in contact with a liquid. Zeta potential is not a directly measurable parameter. It can be determined using appropriate theoretical models from experimentally determined parameters, which depend on electric charge separation at interfaces. “Electrokinetic phenomena” encompass such experimentally observed effects. A group of electrokinetic phenomena at high frequency on MHz scale is referred to as “electroacoustics”.[1] Each classical electrokinetic phenomenon at DC or low AC conditions has electroacoustic analogue. These electroacoustic phenomena have been widely used to determine electrophoretic mobility of various concentrated particulates without sample dilution. The purpose of this part of ISO 13099 in methods for Zeta potential determination is description of general features of such electroacoustic methods that should be common for all instrumental implementation for measuring electrophoretic mobility using electroacoustics and following calculation of zeta potential of particulates.

Colloidal systems — Methods for zeta potential determination —

Part 3:
Acoustic methods

1 Scope

This part of ISO 13099 describes in general electroacoustic effects that can be defined as high frequency electrokinetic phenomena.

Particular attention is given to two methods of measurement of electrophoretic mobility of particles suspended in a liquid at high concentration above 1 % v/v, colloid vibration current (CVI)[2] and electric sonic amplitude (ESA),[3] [4] respectively.

Estimation of surface charge and determination of zeta potential can be achieved from measured electrophoretic mobility using proper theoretical models, which are described in detail in ISO 13099-1.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 13099-1, *Colloidal systems — Methods for zeta-potential determination — Part 1: Electroacoustic and electrokinetic phenomena*

ISO 13099-2, *Colloidal systems — Methods for zeta-potential determination — Part 2: Optical methods*

3 Terms, definitions and symbols

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

3.1 Electric double layer (EDL)

The electric double layer (EDL) is a 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.

3.1.1
Debye-Hückel approximation
model assuming small electric potentials in the electric double layer

3.1.2
Debye length
κ^{-1}
characteristic length of the electric double layer in an electrolyte solution

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

3.1.3
diffusion coefficient
D
mean squared displacement of a particle per unit time

Note 1 to entry: The diffusion coefficient is expressed in metre squared per second.

3.1.4
Dukhin number
Du
dimensionless number which characterizes contribution of the surface conductivity in electrokinetic and electroacoustic phenomena, as well as in conductivity and dielectric permittivity of heterogeneous systems

3.1.5
dynamic viscosity
η
ratio of the applied shear stress and the rate of shear of a liquid

Note 1 to entry: For the purpose of this part of ISO 13099, dynamic viscosity is used as a measure of resistance of a fluid which is being deformed by shear stress.

Note 2 to entry: Dynamic viscosity determines the dynamics of an incompressible Newtonian fluid.

Note 3 to entry: Dynamic viscosity is expressed in pascal seconds.

3.1.6
electric surface charge density
σ
charges on 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.

3.1.7
electric surface potential
ψ^s
difference in electric potential between the surface and the bulk liquid

Note 1 to entry: Electric surface potential is expressed in volts.

3.1.8
ζ - potential
electrokinetic potential
zeta 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.

3.1.9
Gouy-Chapman-Stern model
model describing the electric double layer

3.1.10
isoelectric point
condition of liquid medium, usually the value of pH, that corresponds to zero zeta-potential of dispersed particles

3.1.11
slipping plane
shear 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

3.1.12
Stern potential
ψ_d
electric potential on the external boundary of the layer of specifically adsorbed ions

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

3.2 Electrokinetic phenomena

Note 1 to entry Electrokinetic phenomena are associated with tangential liquid motion adjacent to a charged surface.

3.2.1
electroosmosis
motion of liquid through or past a charged surface, e.g. an immobilized set of particles, a porous plug, a capillary or a membrane, in response to an applied electric field, which is the result of the force exerted by the applied field on the countercharge ions in the liquid

3.2.2
electroosmotic counter-pressure
Δp_{eo}
pressure difference that is applied across the system to stop the electroosmotic flow

Note 1 to entry: The electroosmotic counter-pressure value is positive if the high pressure is on the higher electric potential side.

Note 2 to entry: Electroosmotic counter-pressure is expressed in pascals.

3.2.3
electroosmotic velocity
v_{eo}
uniform velocity of the liquid far from the charged interface

Note 1 to entry: Electroosmotic velocity is expressed in metres per second.

3.2.4
electrophoresis
movement of charged colloidal particles or polyelectrolytes, immersed in a liquid, under the influence of an external electric field

3.2.5
electrophoretic mobility
μ
electrophoretic velocity per unit electric field strength

Note 1 to entry: Electrophoretic mobility is positive if the particles move toward lower potential (negative electrode) and negative in the opposite case.

Note 2 to entry: Electrophoretic mobility is expressed in metres squared per volt second.

3.2.6
electrophoretic velocity
v_e
particle velocity during electrophoresis

Note 1 to entry: Electrophoretic velocity is expressed in metres per second.

3.2.7
sedimentation potential
U_{sed}
potential difference sensed by two electrodes placed some vertical distance apart in a suspension in which particles are sedimenting under the effect of gravity

Note 1 to entry: When the sedimentation is produced by a centrifugal field, the phenomenon is called centrifugation potential.

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

3.2.8
streaming current
I_{str}
current through a porous body resulting from the motion of fluid under an applied pressure gradient

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

3.2.9
streaming current density
J_{str}
streaming current per area

Note 1 to entry: Streaming current density is expressed in coulombs per square metre.

3.2.10
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.

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

3.2.11
surface conductivity
K^{σ}
excess electrical conduction tangential to a charged surface

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

3.3 Electroacoustic phenomena

Electroacoustic phenomena arise due to the coupling between the ultrasound field and electric field in a liquid that contains ions. Either of these fields can be primary driving forces. Liquid might 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.

3.3.1
colloid vibration current
CVI
a.c. current generated between two electrodes, placed in a dispersion, if the latter is subjected to an ultrasonic field

Note 1 to entry: Colloid vibration current is expressed in amperes.

3.3.2
colloid vibration potential
CVU
a.c. potential difference generated between two electrodes, placed in a dispersion, if the latter is subjected to an ultrasonic field

Note 1 to entry: Colloid vibration potential is expressed in volts.

3.3.3
electrokinetic sonic amplitude
ESA
amplitude is created by an a.c. electric field in a dispersion with electric field strength, E; it is the counterpart of the colloid vibration potential method

Note 1 to entry: See References [3] and [4].

Note 2 to entry: Electrokinetic sonic amplitude is expressed in pascals.

3.3.4
ion vibration current
IVI
a.c. electric current created from different displacement amplitudes in an ultrasound wave due to the difference in the effective mass or friction coefficient between anion and cation

Note 1 to entry: See Reference [5].

Note 2 to entry: Ion vibration current is expressed in amperes.

3.3.5
seismoelectric effect
SEI
non-isochoric streaming current that arises in a porous body when an ultrasound wave propagates through

Note 1 to entry: See References [6] and [7].

Note 2 to entry: A similar effect can be observed at a non-porous surface, when sound is bounced off at an oblique angle.[11]

Note 3 to entry: Seismoelectric effect is expressed in amperes.

3.3.6
electroseismic effect
ESI
non-isochoric electroosmotic pressure wave that arises in a porous body under influence of high frequency electric field

Note 1 to entry: See References [6] and [7].

Note 2 to entry: Electroseismic effect is expressed in pascals.

3.3.7
dynamic electrophoretic mobility
μ_d
electrophoretic velocity per unit electric field strength in high frequency (MHz) electric field

Note 1 to entry: Traditional electrophoretic mobility is low frequency asymptotic of the dynamic electrophoretic mobility.

Note 2 to entry: Electrophoretic mobility is expressed in metres squared per volt second.

