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Colloidal systems — Methods for zeta-potential determination —

Part 2: Optical methods

Systèmes colloïdaux — Méthodes de détermination du potentiel zêta —

Partie 2: Méthodes optiques

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Foreword

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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

This second edition cancels and replaces the first edition (ISO 13099-2:2012), which has been technically revised.

The main changes are as follows:

— addition of new terms and definitions;

— revision of Figure 3, illustrating instrument configuration;

— removal of section on cross-beam optics;

— revision of the description of phase analysis light scattering (PALS);

— addition of information on cell constant.

A list of all parts in the ISO 13099 series can be found on the ISO website.

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

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 adsorption on 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, such as electrophoretic mobility.

Optical methods, especially electrophoretic light scattering, have been widely used to determine electrophoretic mobility of particles or macromolecules in suspension or in solution. The purpose of this document is to provide methods for measuring electrophoretic mobility using optical means and for calculating zeta-potential.

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Colloidal systems — Methods for zeta-potential determination —

Part 2: Optical methods

IMPORTANT — This document is to be read in conjunction with ISO 13099-1, which gives a comprehensive overview of the theory.

1 Scope

This document specifies two methods of measurement of the electrophoretic mobility of particles suspended in a liquid: video microscopy and electrophoretic light-scattering.

NOTE 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

There are no normative references for this document,

3 Terms, definitions and symbols

3.1 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/

3.1.1
Brownian motion
random movement of particles suspended in a liquid caused by thermal movement of medium molecules

3.1.2
cell constant
proportional constant between the applied electric field, either in a constant voltage or a constant current, and the electric field strength in the measurement zone of the sample cell, which is unique for each cell and can be obtained by measuring a medium with known conductivity

3.1.3
Doppler shift
change in frequency and wavelength of a wave for an observer moving relative to the source of the wave

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3.1.4
zeta-potential
electrokinetic potential
ζ-potential
ζ
difference in electric potential between that at the slipping plane and that of the bulk liquid

Note 1 to entry: Zeta-potential is expressed in volts.

3.1.5
electroosmosis
motion of liquid through or past a charged surface in response to an applied electric field, which is the result of the force exerted by the applied field on the counter-charge ions in the liquid

Note 1 to entry: A charged surface can include an immobilized set of particles, a porous plug, a capillary or a membrane.

3.1.6
electroosmotic velocity
$\boldsymbol{v_{eo}}$
uniform velocity of the liquid far from the charged interface

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

3.1.7
electrophoretic mobility
$\boldsymbol{\mu}$
electrophoretic velocity per 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.

3.1.8
electrophoretic velocity
$\boldsymbol{v_e}$
particle velocity during electrophoresis

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

3.1.9
intermediate precision
measurement precision under set of intermediate precision conditions of measurement

[SOURCE: ISO/IEC Guide 99:2007, 2.23]

3.1.10
slipping plane
shear plane
abstract plane in the vicinity of the interface between liquid and solid where liquid starts to slide relative to the surface under influence of a shear stress

3.1.11
trueness
closeness of agreement between the average of an infinite number of replicate measured quantity values and a reference quantity value

[SOURCE: ISO/IEC Guide 99:2007, 3.17]

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3.2 Symbols

a	particle radius
D	diffusion coefficient
E	electric field strength
k_B	Boltzmann constant
I	light intensity
N_A	Avogadro's number
n	medium refractive index
R_{cap}	capillary radius
$S(\omega)$	frequency power spectrum of scattering
Γ	characteristic Lorentzian half peak width
ε	medium permittivity
ζ	zeta-potential (electrokinetic potential)
η_0	medium viscosity
θ	angle between incident light and scattered light
κ	reciprocal Debye length
λ	wavelength
μ	electrophoretic mobility
μ_{eo}	electroosmotic mobility of liquid
ν	frequency
ξ	angle between scattered light and electric field direction
τ	delay time in autocorrelation function
φ	volume fraction
ω	rotational frequency (= $2\pi\nu$)

4 Principles

A suspension of particles having a given electrokinetic charge is placed in a cell which has a pair of electrodes placed some distance apart (see Figure 1). This cell can be in the form of either a cylindrical or rectangular capillary with electrodes at either end, or a pair of electrodes at a known fixed distance apart that are dipped into a cuvette or other vessel. A potential is applied between the electrodes. Due to the process of electrophoresis, particles carrying a net negative charge are drawn towards the electrode of opposite sign and vice versa. In addition, if the capillary walls are charged, then an effect called electroosmosis causes the liquid to stream along the capillary walls. The direction and velocity of this flow depends on the sign and magnitude of the wall charge. The resulting velocity of the particle in the frame of references associated with the cell is superposition of the electrophoretic velocity and the velocity of electroosmotic flow. The time taken for the particle to reach the terminal electrophoretic velocity after the application of the electric field is much shorter than the period of time needed to fully establish the electroosmosis flow throughout the whole cell. This difference is exploited in some implementations. The velocity of the particles measured at a specific position can be determined using either video microscope or electrophoretic light scattering through a laser Doppler arrangement. Both the velocity and the direction of the moving particles in the frame of references associated with the cell are determined. Provided that the distance between the electrodes is known together with the applied electric potential, then the electrophoretic mobility can be established, from which a zeta-potential can be calculated using established theories. Alternatively, calibration with particles having a known zeta-potential can be used to eliminate the need to determine the unknown cell constant of a particular cell.

There are two distinctively different approaches to monitor particle motion in the electric field. Historically, the first deals with particle images observed through a microscope. It is referred to as the "microscopic method", or alternatively as "microelectrophoresis". The second relies on measuring light scattered by

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