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Determination of particle density by sedimentation methods —

Part 2:
Multi-velocity approach

Détermination de la densité de particules par méthodes de sédimentation —

Partie 2: Approche à multi vitesses

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

A list of all parts in the ISO 18747 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.

Introduction

Dispersions are widely used in industry and everyday life. There is a need to understand the density of dispersed particles or droplets, e.g. for physico-chemical calculations such as kinematic viscosity of dispersions[1], determination of particle size distribution by sedimentation[2][3] or acoustic techniques[4], particle characterization by field-flow approaches[5], optimization of dispersion long-term stability by density matching[6] as well as, more generally, characterization of particles (e.g. composition, internal phase content of double emulsions or homogeneity of hollow capsules) in manifold academic and industrial areas. Nowadays there is an increasing interest in using particle density to estimate the mass transfer of nanoparticles atop cell layers by sedimentation (dosage calculation for in vitro nanotoxicity assessment[7][8][9]).

The density of a body is defined as its mass divided by its volume. This calculation is straightforward for a large uniform body or particle. However, determination of the volume of a macroscopic body is difficult. The geometrical volume (defined by length, width and thickness) and the volume relevant for the determination of density may differ due to surface irregularities, fractures, fissures and pores or the measuring techniques employed.

Density determination of micro-particles, especially nanoparticles dispersed in a liquid, is difficult not only due to the determination of mass and volume for small particles, but also due to the fuzzy boundary between the liquid and the particle, which is often described in terms of a corona[10]. Liquid and solute molecules in the continuous phase are partially immobilized at the surface. Physico-chemical properties (e.g. viscosity, ion composition, solute concentration) in the fuzzy coat differ from the bulk. This effect is especially important for small microparticles and nanoparticles that are dispersed in a polymer or biological media[11]. The so-called corona may be interpreted as an integral part of the particle and increases the effective/apparent volume compared to the space occupied by the dry particle. The thickness of this layer ranges between a few to tens of nanometres. The effective/apparent volume deviates increasingly from the “geometrical” volume of dry particles as the particles become smaller. Correspondingly, density determination by traditional methods is affected. These concerns hold also for particle size, which may refer to different geometrical and physical properties. In the context of this document, the Stokes diameter and diameter of the enveloping sphere/hull are particularly relevant.

Determination of particle density by sedimentation methods —

Part 2:
Multi-velocity approach

1 Scope

This document specifies an in situ method for the determination of the density of solid particles or liquid droplets (herein referred to as "particle") dispersed in liquid continuous phase. The method is based on direct experimental determination of particle velocity in these liquids or media in gravitational or centrifugal fields based on Stokes law. The particle density is calculated from experimentally determined particle velocities in different liquids or media, taking into account their dynamic viscosities and densities, respectively. The approach does not require the knowledge of particle size distribution but assumes that sedimentation relevant characteristics (e.g. volume, shape, agglomeration state) do not change. This document does not consider polydispersity with regard to particle density, i.e. all particles are assumed to be of the same material composition.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 14887, *Sample preparation — Dispersing procedures for powders in liquids*

3 Terms and definitions

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

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

— IEC Electropedia: available at http://www.electropedia.org/

— ISO Online browsing platform: available at https://www.iso.org/obp

3.1
buoyant density
ratio of particle mass to particle volume including filled or closed pores as well as adjacent layers of liquid or other coating materials

3.2
dynamic viscosity
measure of the resistance of a fluid which is being deformed by shear stress

Note 1 to entry: Dynamic viscosity is calculated by shear stress divided by shear rate and determines the dynamics of an incompressible Newtonian fluid.