PD ISO/TS 21236-1:2019

BSI Standards Publication

Nanotechnologies — Clay nanomaterials

Part 1: Specification of characteristics and measurement methods for layered clay nanomaterials

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National foreword

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The UK participation in its preparation was entrusted to Technical Committee NTI/1, Nanotechnologies.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Published by BSI Standards Limited 2019

ISBN 978 0 539 01726 7

ICS 07.120

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This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2019.

Amendments/corrigenda issued since publication

Date	Text affected

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TECHNICAL SPECIFICATION

ISO/TS 21236-1

First edition
2019-10

Nanotechnologies — Clay nanomaterials —

Part 1: Specification of characteristics and measurement methods for layered clay nanomaterials

Nanotechnologies — Nano argiles —

Partie 1: Spécification des caractéristiques et des méthodes de mesure des nano argiles en couches

Reference number
ISO/TS 21236-1:2019(E)

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Published in Switzerland

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Foreword

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This document was prepared by Technical Committee ISO/TC 229, *Nanotechnologies*.

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Introduction

Layered clay nanomaterials are a subgroup of clay materials with the external dimension (thickness) or the internal structural dimension (interlayer distance) in the nanoscale. Clay itself, as most important group of layered nanostructured silicates, refers to naturally occurring or synthetic material composed primarily of fine-grained minerals, which show plasticity through a variable range of water content and will harden when fired or dried. The minerals found in clay are generally silicates of less than 2 micrometres in lateral size. Clays are very abundant at the earth's surface; they form rocks known as shales and are a major component in nearly all sedimentary rocks. The small size of the particles and their unique crystal structures give clay materials special properties, including cation exchange capabilities, plastic behaviour when wet, catalytic abilities, swelling behaviour, and low permeability[1].

Other than the structure and composition, there are several additional factors which are important in determining the properties and applications of clays and clay nanomaterials (see Annex A). These are the mineral impurities, the presence of organic materials, the type and amount of exchangeable ions and soluble salts, and the morphological aspects[2].

Natural and modified clays as layered structured minerals are very important industrial materials. In pristine form, clay materials are normally subnano spaced layers, structured in bundles and in exfoliated state; they are nano-objects with thickness in the nanoscale while in intercalated form they are structured nanomaterials with interlayer space in nanoscale.

Modification of clay with change in its characteristic such as its hydrophobicity, interlayer distance, exchangeable ion, and surface connected groups leads to the extension of its applications e.g. for high performance nanocomposites, effective rheological modifier, or biomedical applications. A small quantity of well dispersed intercalated or exfoliated organo-modified layered clay nanomaterials in polymeric composites (see Annex B) is proved to show superior impacts on properties such as barrier, tensile modulus, mechanical strength, and flame retardancy.

There are numerous industrial applications for layered clay nanomaterials. Purified and modified clays are used as; coatings on paper to enhance whiteness and to allow the proper absorption of ink, the life time extender of rubber in tires, in concrete, as catalysts in many industries. Moreover, they can also be used in oil purification, pharmaceuticals, ceramic industry, soil stabilization, porcelains and barriers for nuclear and chemical wastes because of their cation-exchange capabilities, low permeability, and long-term structural stability. In addition, layered clay nanomaterials are utilized in purification industries, in agricultural and food engineering applications, polymeric nanocomposites, deodorizer, insecticide carrier, pesticides carrier, drilling fluids, desiccant, detergents, plasticizer, emulsion stabilizer, food additives, cosmetic applications, environmental remediation and many other miscellaneous applications[1][2].

For such a wide range of clay nanomaterial applications, various fundamental characteristics (as shown in Table 1) play undeniable roles. These characteristics are measured and reported by the provider of the layered clay nanomaterials. In fact, the determinations of these fundamental and basic characteristics will facilitate the communication between sellers and buyers of these nanomaterials for different applications. These characteristics are considered for all industrial layered clay nanomaterial applications such as nanocomposites, paper, ink, purification, and catalysts. In addition to fundamental characteristics, presented in Table 1, some other optional characteristics of layered clay nanomaterials as shown in Table 2 are measured and reported subject to the agreement between sellers and buyers.

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Nanotechnologies — Clay nanomaterials —

Part 1: Specification of characteristics and measurement methods for layered clay nanomaterials

1 Scope

This document specifies characteristics to be measured of layered clay nanomaterials in powder form and chemically modified ones, and describes their relevant measurement methods.

This document does not deal with health, safety and environmental issues.

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 terminological databases for use in standardization at the following addresses:

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

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

3.1
aspect ratio
ratio of the sheet length to the sheet width

[SOURCE: ISO 8336:2017,3.13]

3.2
bulk density
ratio of the mass of an untapped powder sample and its volume including the contribution of the interparticulate void volume

3.3
cation exchange capacity
amount of exchangeable cations per defined mass of clay nanomaterial sample

3.4
clay
naturally occurring or synthetically manufactured material composed primarily of fine-grained minerals, which is generally plastic at appropriate water contents and will harden when dried or fired

Note 1 to entry: Taken from Reference [3].

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Note 2 to entry: Although clay usually contains phyllosilicates, it may contain other materials that impart plasticity and harden when dried or fired. Associated phases in clay may include materials that do not impart plasticity and organic matter. Different disciplines have uniquely defined the size of clay particles, and it is for this reason that "fine grained" is used in the definition rather than a precise value. However, because of these size variations from discipline to discipline, it is important that the particle size be specified in the context of the application.

3.5
clay nanomaterials
material composed predominately of clay with any external dimension in the nanoscale or having internal structure or surface structure in the nanoscale

3.6
exchangeable ion
ions bearing in clays which can be exchanged with other ions

Note 1 to entry: See Reference [4].

3.7
exfoliated clay
state of separating clay layers and distributing individual layers

Note 1 to entry: Usually exfoliation of layered clay nanomaterials is conducted in liquid suspension by giving shear forces.

Note 2 to entry: See Reference [5].

3.8
film formability
ability of clay to form self-standing films (uniform and ordered lamination of clay layers)

Note 1 to entry: See Reference [6].

3.9
gallery thickness
distance between clay layers

3.10
intercalated clay
clay in which heterogeneous material (atoms, molecules and nanoparticles) is inserted into a host structure (crystal lattice or other macromolecular structure)

3.11
interlayer distance
distance between identical adjacent layers of clay which is sum of gallery thickness (height) and thickness of a single sheet of clay (d_s)

3.12
layer
discrete material restricted in one dimension, within or at the surface of a condensed phase

[SOURCE: ISO/TS 80004-11:2017, 3.1.2]

3.13
layered clay nanomaterial
clay nanomaterial composed of one or more structural layer

3.14
loss on ignition
dried sample's weight loss during a heat treatment up to 1 000 °C

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