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Nanotechnologies — Superhydrophobic surfaces and coatings: Characteristics and performance assessment

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National foreword

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Foreword

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

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

Surfaces or coatings which are extremely difficult to wet with water can be considered as superhydrophobic. Based on the scientific literature, superhydrophobic surfaces and coatings show contact angles of above 150° as well as contact angle hysteresis less than 10°. Superhydrophobicity phenomena is seen in some natural species, e.g. lotus leaves. Another related term is "lotus effect" which arises for droplets in the Cassie-Baxter wetting state.

Various methods have been utilized for the production of superhydrophobic surfaces and coatings, e.g. chemical vapour deposition, spin coating, sputtering, plasma deposition, chemical etching, sol-gel, photolithography, anodizing and plasma electrolyte oxidation. The superhydrophobic surfaces and coatings have numerous applications in different industries due to their properties, which can include self-cleaning, anti-corrosion, anti-icing, anti-fog and antibacterial effects. Such coatings and surfaces are gradually entering automotive, building and construction, healthcare, optical and electrical industries. The market for superhydrophobic surfaces and coatings for 2020 was about $1,8 billion[1].

A common characteristic of superhydrophobic surfaces and coatings is their proper two-level topography (i.e. micro- and nano-sized asperities) combined with low surface energy. This multiscale (hierarchical) roughness would result in large water contact angle, low contact angle hysteresis, and high wetting stability against the Cassie–Baxter to Wenzel transition. In other words, a large contact angle is already achievable with a microscale surface roughness but for having a large contact angle combined with small contact angle hysteresis, nanoscale roughness is needed[3]. In other words, water cannot penetrate into nano-scale surface asperities which results in small contact angle hysteresis. In the absence of nano roughness, penetration of water into the micro-scale surface asperities results in high contact angle hysteresis (see Annex A). Such surfaces (surfaces with contact angles above 150° and contact angle hysteresis more than 10°) are called "pseudo-superhydrophobic" surfaces[3]; another related term for pseudo-superhydrophobic is "sticky superhydrophobic", that arises due to the rose petal effect for droplets being in the Wenzel state.

Water droplets easily bead up and roll-off on superhydrophobic surfaces and coatings and this easy roll-off is the root cause of all the interesting properties of superhydrophobic surfaces and coatings. Advancing and receding angles are the parameters used to quantify the droplet mobility on surfaces. As such, measuring the advancing and receding angles identifies if a coating/surface has superhydrophobic properties. Also, measuring the advancing and receding angles before and after exposing the surface to different working/environmental conditions can be used to assess the performance of superhydrophobic surfaces and coatings.

The superhydrophobic surfaces and coatings are normally subjected to different working/environmental conditions, for example, mechanical stress, ultra-violet (UV), visible and infrared (IR) exposure, exposure to different liquids and thermal cycling. These conditions may lead to possible alteration of the performance of superhydrophobic surfaces and coatings. Unfortunately, despite the huge market, there is currently no standard to assess the durability of superhydrophobic surfaces and coatings. This document aims to specify performance assessment methods of superhydrophobic surfaces and coatings under different working/environmental conditions, where applicable, based on the agreement between interested parties. The assessment criteria are comparison of advancing angle, receding angle and contact angle hysteresis of the samples before and after being subjected to the above-mentioned working/environmental conditions. Further, this document facilitates the communication between the interested parties. Also, this document supports UN sustainable development goals (SDGs) 8 and 12 which are "decent work and economic growth" and "responsible consumption and production".

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TECHNICAL SPECIFICATION **ISO/TS 10689:2023**

Nanotechnologies — Superhydrophobic surfaces and coatings: Characteristics and performance assessment

1 Scope

This document specifies requirements and recommendations for performance assessment methods for superhydrophobic surfaces and coatings subjected to mechanical stress, solar radiation and weathering, liquids, and thermal cycling, where applicable, based on the agreement between interested parties. The performance assessment is carried out based on comparative measurements of the advancing and receding angles and the calculation of the contact angle hysteresis before and after the above-mentioned working/environmental conditions. This document does not address safety and environmental related issues of such coatings.

This document is applicable to any superhydrophobic surfaces and coatings (i.e. nanostructured) on which the measurement of the advancing and receding angles is possible.

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 2812-1, *Paints and varnishes — Determination of resistance to liquids — Part 1: Immersion in liquids other than water*

ISO 7784-3, *Paints and varnishes — Determination of resistance to abrasion — Part 3: Method with abrasive-paper covered wheel and linearly reciprocating test panel*

ISO 11997-3, *Paints and varnishes — Determination of resistance to cyclic corrosion conditions — Part 3: Testing of coating systems on materials and components in automotive construction*

ISO 16474-2, *Paints and varnishes — Methods of exposure to laboratory light sources — Part 2: Xenon-arc lamps*

ISO 19403-6:2017, *Paints and varnishes — Wettability — Part 6: Measurement of dynamic contact angle*

ISO/TR 21555:2019, *Paints and varnishes — Overview of test methods on hardness and wear resistance of coatings*

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
abrasion
wear which is caused by removal of coating materials on a surface

[SOURCE: ISO/TR 21555:2019, 3.6]

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