International Standard

ISO 19403-5

Paints and varnishes — Wettability —

Part 5:
Determination of the polar and dispersive fractions of the surface tension of liquids from contact angles measurements on a solid with only a disperse contribution to its surface energy

Peintures et vernis — Mouillabilité —

Partie 5: Détermination des fractions polaire et dispersive de la tension superficielle des liquides à partir de mesurages de l'angle de contact avec un solide n'ayant qu'une contribution de dispersion à son énergie de surface

**Second edition
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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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This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 139, *Paints and varnishes*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This second edition cancels and replaces the first edition (ISO 19403-5:2017), which has been technically revised.

The main changes are as follows:

— in 7.4, information on the dynamic contact angle measurement has been added;

— the normative references have been updated.

A list of all parts in the ISO 19403 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.

Paints and varnishes — Wettability —

Part 5:
Determination of the polar and dispersive fractions of the surface tension of liquids from contact angles measurements on a solid with only a disperse contribution to its surface energy

1 Scope

This document specifies a test method to determine the polar and dispersive fractions of the surface tension of liquids by optical methods. The method can be applied for the characterization of liquid coating materials.

If applied to liquids with non-Newtonian flow behaviour (see ISO 3219-1:2021, 3.22), restrictions can apply.

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 1409, *Plastics/rubber — Polymer dispersions and rubber latices (natural and synthetic) — Determination of surface tension*

ISO 4618, *Paints and varnishes — Vocabulary*

ISO 15528, *Paints, varnishes and raw materials for paints and varnishes — Sampling*

ISO 19403-1, *Paints and varnishes — Wettability — Part 1: Vocabulary and general principles*

ISO 19403-2, *Paints and varnishes — Wettability — Part 2: Determination of the surface free energy of solid surfaces by measuring the contact angle*

ISO 19403-3, *Paints and varnishes — Wettability — Part 3: Determination of the surface tension of liquids using the pendant drop method*

EN 14370, *Surface active agents — Determination of surface tension*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 4618 and ISO 19403-1 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/

4 Principle

The following steps apply.

— Step 1: The surface tension of the liquid to be tested is determined according to ISO 19403-3, EN 14370 or ISO 1409.

— Step 2: The surface free energy of a reference solid without polar fraction of the surface free energy is determined according to ISO 19403-2.

— Step 3: Measurement of the contact angle between the reference solid and the liquid to be tested is carried out according to ISO 19403-2.

 NOTE Measurements can be static or dynamic.

— Step 4: The dispersive fraction of the surface tension of the liquid is calculated according to Owens, Wendt, Rabel and Kaelble (OWRK)[5], [6], [7] or according to Wu.

— Step 5: The polar fraction of the surface tension of the liquid is calculated from the dispersive fraction of the surface tension and the surface tension measured in step 1.

5 Reference solid

Use a sufficiently, chemically and topologically homogenous dispersive solid, e.g. made of paraffin or PTFE.

NOTE 1 For the application of this document, surfaces of solids with a polar fraction of <0,5 mJ/m^2 are sufficiently dispersive.

Sufficiently homogenous PTFE reference surfaces preferably have a surface free energy of (18,5 ± 0,5) mJ/m^2 according to the OWRK method. Surface free energies which are locally measured on the reference surface for the determination of the standard deviation (see 8.1) are measured in accordance with 7.3. For the PTFE surfaces, as well as the paraffin surfaces, precise reference objects with a mean roughness value, R_a, of less than 0,3 μm are recommended. The paraffin reference surfaces preferably have a surface free energy of (25,5 ± 0,5) mJ/m^2 under the same conditions as the PTFE reference surfaces.

NOTE 2 The roughness value (R_a) is defined in ISO 21920-3 and ISO 25178-2.

6 Sampling

Take a representative sample of the liquid to be tested in accordance with ISO 15528.

7 Procedure

7.1 Test conditions

Carry out the test at (23 ± 2) °C and a relative humidity of (50 ± 5) % (see ISO 3270) and make sure that all test media have this temperature.

7.2 Determination of the surface tension of the liquid to be tested

Measure the surface tension of the liquid to be tested in accordance with ISO 19403-3, EN 14370 or ISO 1409.

7.3 Determination of the surface free energy of the reference solid

If the surface free energy of the reference solid is unknown, determine it in accordance with ISO 19403-2 using at least 10 drops from each of the three test liquids indicated in ISO 19403-2:2024, Table 1.

Calculate the surface free energy in accordance with ISO 19403-2:2024, 8.2 [method according to Owens, Wendt, Rabel and Kaelble (OWRK method) for determining the disperse components of the surface tension

of the liquid] or ISO 19403-2:2024, 8.3 (Wu method for determining the disperse components of the surface tension of the liquid).

NOTE   Since a reference solid with predominantly dispersive interactions is used, it can be assumed that the dispersive fraction of the surface tension of the liquid can be determined from a single contact angle value.

7.4   Determination of the contact angle of the liquid to be tested on the reference solid

Clean, dry and condition the reference solid in accordance with ISO 19403-2. Measure the contact angle between the reference solid and the liquid to be tested in accordance with ISO 19403-2. Use at least 10 drops for this. Use the same method (static or dynamic) as in 7.3 for measuring the contact angle. The dynamic contact angle measurement is better defined and is more reproducible.

8   Evaluation

8.1   General

The standard deviations should not exceed the following values:

— for the surface tension of the tested surface: ±1 %;

— for the surface free energy of the reference solid: preferably 0,3 mJ/m^2, not exceeding 0,5 mJ/m^2;

— for the contact angles of the tested liquid on the reference solid: for the static method 1° and for the dynamic method 3°.

8.2   Owens-Wendt-Rabel-Kaelble method (OWRK method)

For reference surfaces with a surface free energy >20 mJ/m^2, calculate the dispersive fraction of the surface tension of the liquid, σ_l^d, in accordance with Formula (1):

$$\sigma_l^d = \frac{(1+\cos\theta)^2 \cdot \sigma_l^2}{4\sigma_s} \tag{1}$$

where

θ is the mean value of the measured contact angles between the tested liquid and the reference solid;

σ_l is the surface tension of the tested liquid, measured in accordance with 7.2;

σ_s is the surface free energy of the reference solid, measured in accordance with 7.3.

8.3   Wu method

For reference surfaces with a surface free energy < 20 mJ/m^2, calculate the dispersive fraction of the surface tension of the liquid, σ_l^d, in accordance with Formula (2):

$$\sigma_l^d = \frac{\sigma_l \sigma_s^d (1+\cos\theta)}{4\sigma_s^d - \sigma_l (1+\cos\theta)} \tag{2}$$

where

θ is the mean value of the measured contact angles between the tested liquid and the reference solid;

σ_l is the surface tension of the tested liquid, measured in accordance with 7.2;

σ_s^d is the dispersive fraction of the surface energy of the reference solid.

8.4 Calculation of the polar fraction of the surface tension of the liquid

Calculate the polar fraction of the surface tension of the liquid, σ_l^p, in accordance with Formula (3):

$$\sigma_l^p = \sigma_l - \sigma_l^d \tag{3}$$

where

σ_l is the surface tension of the tested liquid, measured in accordance with 7.2;

σ_l^d is the dispersive fraction of the surface tension of the tested liquid.

9 Test report

The test report shall contain at least the following information:

a) all details necessary to identify the tested product;

b) a reference to this document, i.e. ISO 19403-5:2024;

c) the surface tension of the liquid to be tested including all information in accordance with the test report of the method used;

d) the surface free energy of the reference solid including all information on the test report of the method used, or information on the reference documents, the material under test and the manufacturer, cleaning and preparation method of the reference solid, if applicable;

e) for the determination of the polar and dispersive fractions of the surface tension of the liquid:

   1) the information on whether the dynamic advancing, recently advanced, static, recently receded or dynamic receding contact angle was measured,

   2) the used drop volumes or volume range and dosing speed,

   3) the method with which the contact angle of the drop was obtained,

   4) the amount of drops,

   5) the amount of measuring points per drop,

   6) the result of the measurement of the contact angle (arithmetic mean value and standard deviation),

   7) the result of the calculation of the polar and dispersive fraction of the surface tension of the liquid,

   8) the information on whether it was calculated in accordance with Owens-Wendt-Rabel-Kaelble or Wu;

f) the random error for the calculation of the surface free energy of the reference solid as well as the polar and dispersive fractions of the surface tension of the liquid;

g) any deviations from the specified method and their possible influences on the results;

h) any unusual observation during the test;

i) the type of device;

j) the name of the person conducting the test;

k) the date of the test.