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

Peintures et vernis — Mouillabilité —

*Partie 2: Détermination de l'énergie libre de surface des surfaces
solides par la mesure de l'angle de contact*

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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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For an explanation on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 35, *Paints and varnishes*, Subcommittee SC 9, *General test methods for paints and varnishes*.

A list of all parts in the ISO 19403 series can be found on the ISO website.

Paints and varnishes — Wettability —

Part 2:

Determination of the surface free energy of solid surfaces by measuring the contact angle

1 Scope

This document specifies a test method to measure the contact angle for the determination of the surface free energy of a solid surface. The method can be applied for the characterization of substrates and coatings.

NOTE 1 For the determination of the surface free energy of polymers and coatings, either the method in accordance with Owens, Wendt, Rabel and Kaelble or the method in accordance with Wu is used preferably.

NOTE 2 The morphological and chemical homogeneity have an influence on the measuring results.

NOTE 3 The procedures indicated in this document are based on the state-of-the-art employing the drop projection method in penumbral shadow. Other methods are not excluded.

NOTE 4 Measuring the contact angle on powders is not part of this document. For further information, see the bibliography.

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 4618, *Paints and varnishes — Terms and definitions*

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

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 terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

4 Principle

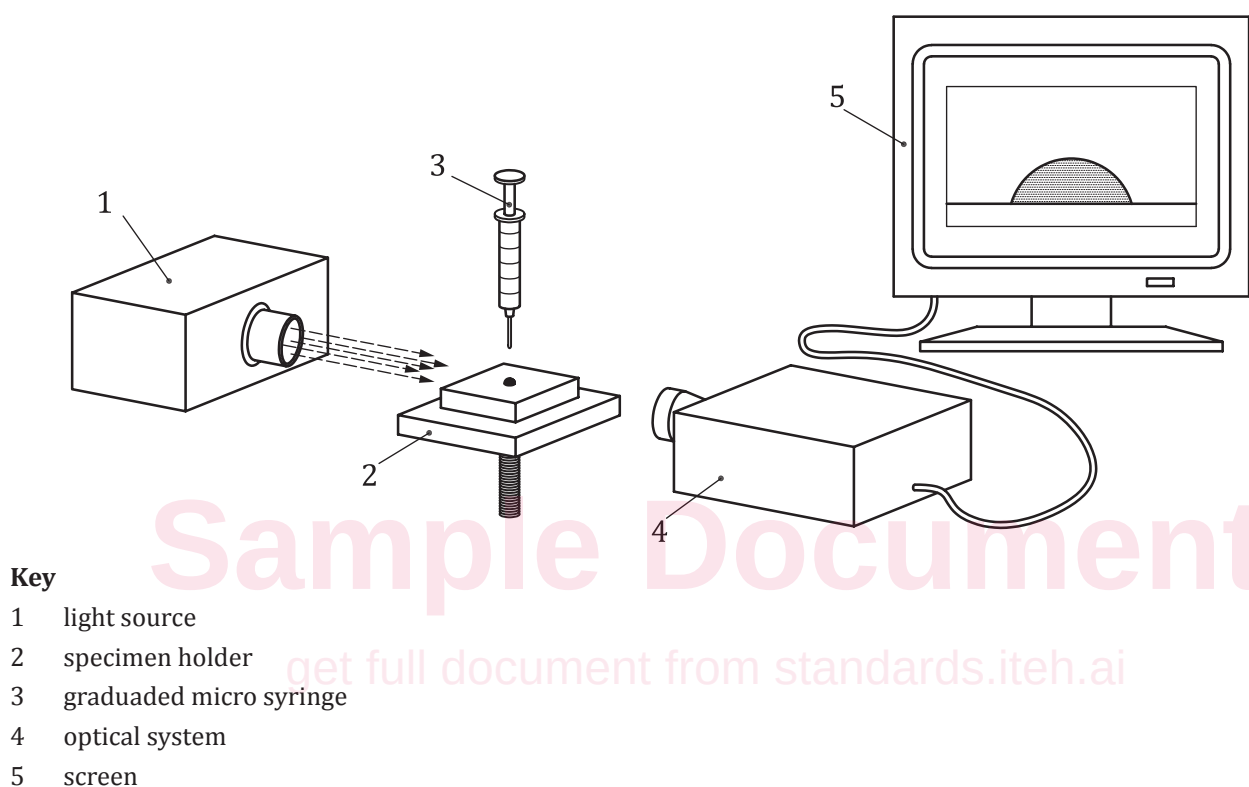
A minimum of three drops of at least two test liquids are dosed onto the flat surface of a test specimen. For every drop, the contact angle is measured. From the averaged contact angles of every liquid, their surface tensions, as well as their polar and dispersive fractions, the surface free energy of the solid is calculated by means of an appropriate model, divided into the polar and dispersive fractions.

5 Apparatus and materials

Ordinary laboratory apparatus, together with the following.

5.1 Contact angle measuring system.

Any state-of-the-art contact angle measuring device, preferably systems with digital image capture and analysis for measuring the contact angle. [Figure 1](#) shows a schematic example of a contact angle measuring system.



NOTE 1 The image capturing system is oriented in a way that the optimal image resolution ratio (ratio of width and height) can be used.

NOTE 2 The device used can differ from the schematic diagram in regard to light path and the arrangement of the components.

Figure 1 — Schematic diagram of a contact angle measuring system

5.2 Dosing unit.

The dosing unit makes it possible to precisely apply drops in the range of microlitres to the surface.

5.3 Test liquids.

At least two of the test liquids suggested in [Table 1](#). The test liquids shall have at least “purity grade” for analysis. Water shall have a surface tension of at least 71,5 mN/m.

It is recommended to test the suitability of the liquids used in accordance with ISO 19403-3 or EN 14370 prior to measuring their surface tensions. For guidance, the values from the literature for the surface tension, σ_l , are indicated in [Table 1](#). It is also possible to use an individually measured value of the surface tension as reference value. According to experience, the measured value should not deviate more than ± 2 % from the value from the literature or the individually determined value.

The test liquids shall not physically or chemically affect the surface. The test liquids have a maximum of different polar and dispersive fractions of surface tension.

For at least one of the test liquids used, the polar fractions shall be larger than 0 mN/m (see [Table 1](#)).

In case only two test liquids are used, water and di-iodomethane are recommended. In case three liquids are used, ethylene glycol should be used additionally.

In case of high viscous test liquids like glycerol and ethylene glycol, a needle with higher inner diameter could be necessary to achieve the recommended dosing rate.

NOTE The values in [Table 1](#) refer to 25 °C measuring temperature. For measuring under standard atmosphere (see [7.1.2](#)), no significant deviations can be assumed.

Table 1 — Suggested test liquids

Test liquid	Surface tension σ_l mN/m	Dispersive fraction σ_l^d mN/m	Polar fraction σ_l^p mN/m	Source
Water	72,8	21,8	51,0	Reference [4]
Di-iodomethane ^a	50,8	50,8	0,0	Reference [4]
1,2-ethanediol (ethylene glycol)	47,7	30,9	16,8	Reference [4]
1,2,3-propanetriol (glycerol)	63,4	37,0	26,4	Reference [4]
Hexadecane	27,6	27,6	0,0	Reference [4]
1- bromo- naphthalene ^b	44,6	44,6	0,0	Reference [4]
Benzyl alcohol	38,9	29,0	9,9	Reference [5]
Decalin (isomer mixture)	30,6	30,6	0,0	Reference [4]
cis-Decalin	32,2	32,2	0,0	Reference [2]
trans-Decalin	29,9	29,9	0,0	Reference [2]
^a Di-iodomethane is relative instable, yellowing after short time by splitting-off iodine. Di-iodomethane swells and dissolves a lot of plastics and of organic coatings. Di-iodomethane reacts with common metals (e.g. magnesium). ^b 1-bromo-naphthalene reacts with common metals (e.g. magnesium). 1-bromo-naphthalene tends to swelling and dissolving of high-molecular compounds.				

6 Sampling

Take a representative specimen of the substrate to be tested. The specimens shall not be contaminated before measuring.

Preferably, the specimen should have the minimum size of 10 cm × 10 cm.

See also [Annex A](#).