Designation: D8380 – 21

Standard Test Method for Dry Abrasion Resistance of Hydrophobic and Omniphobic Coatings[1]

This standard is issued under the fixed designation D8380; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This test method describes a procedure for evaluating dry abrasion resistance of a thin hydrophobic or omniphobic coating, or both. The coating is typically less than 100 nm thick and is applied to a planar, glass substrate by application methods including, but not limited to, physical vapor deposition (PVD), dip, or spray.

1.2 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard with the exception of angular measurement which are reported in degrees.

NOTE 1—This test method measures a static contact angle and is not equivalent to Test Method C813 which measures an advancing contact angle.

NOTE 2—Test Method D4060 is not applicable to hydrophobic and omniphobic coatings because the molecular monolayer does not generally result in a detectable weight change to the specimen after subjecting it to abrasion.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C813 Test Method for Hydrophobic Contamination on Glass by Contact Angle Measurement

D16 Terminology for Paint, Related Coatings, Materials, and Applications

D1193 Specification for Reagent Water

D4060 Test Method for Abrasion Resistance of Organic Coatings by the Taber Abraser

D5946 Test Method for Corona-Treated Polymer Films Using Water Contact Angle Measurements

D7490 Test Method for Measurement of the Surface Tension of Solid Coatings, Substrates and Pigments using Contact Angle Measurements

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions*—Definitions used in this test method are in accordance with Terminology D16, unless otherwise specified.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *abrasion cycle, n*—in abrasion testing, one or more movements of the abradant across a material surface, or the material surface across the abradant, that permits a return to its starting position; for this test method, one abrasion cycle is a complete back and forth motion.

3.2.2 *static contact angle, Θ (degrees), n*—the angle between the substrate surface and the tangent line drawn to the droplet surface at the three-phase point, when a liquid drop is resting on a plane solid surface (see Fig. 1).

4. Summary of Test Method

4.1 The coating is applied in a uniform thickness to planar glass panels and, after curing, the surface is abraded using a reciprocating rubbing action under controlled conditions of pressure and abrasive action. Droplets of type IV grade of reagent water are placed on the surface of the specimen, and the contact angle values are measured and then averaged. The test specimen is subjected to abrasion in the same location, until the failure threshold has been reached. Abrasion resistance is assessed by measuring the water contact angle within the abraded area of the test specimen and reporting the number of abrasion cycles.

NOTE 3—A glass substrate was selected because the abradant will wear

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

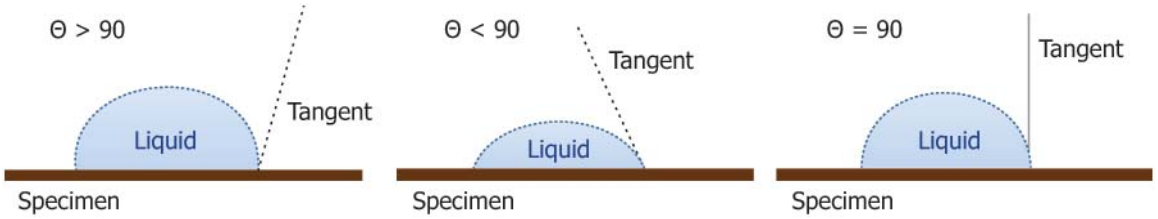

FIG. 1 Contact Angle Examples

the coating before significant damage to the substrate occurs, allowing the failure of the coating to be determined without undesired influence of the substrate system. Other substrate materials may be used, with the understanding that surface finish and wear of the substrate may influence the results.

5. Significance and Use

5.1 The test method is to be used to determine the abrasion resistance or mechanical durability of thin omniphobic or thin hydrophobic coatings. These coatings are often used to enhance the surface's value by promoting fingerprint resistance, water removal, stain resistance, and easy-clean properties. A comparison of the contact angle and the depreciation of that contact angle due to exposure to mechanical abrasion determines the coating's ability to remain effective after exposure to environmental abrasion.

5.1.1 The test method is used to appraise the removal of thin films when gravimetric measurements will not yield a detectable change in film mass due to the small amount of material comprising these films, which are on the order of nanometers thick.

5.1.2 Only fully cured specimens are evaluated unless otherwise specified and agreed upon by the interested parties.

5.2 Different coating materials may be evaluated for relative durability by evaluating abrasion cycles versus water contact angle using this method.

5.3 Different curing or conditioning methods may be evaluated by preparing test specimens with the same coating and then evaluating abrasion resistance using this method.

6. Interferences

6.1 The following factors may interfere with results:

6.1.1 Dirt, fingerprints, or other contamination on the surface being tested.

6.1.2 A rough or porous test surface.

6.1.3 A curved test surface such that angles are difficult to measure.

7. Apparatus

7.1 *Abrader,* consisting of the following elements:

7.1.1 A reciprocating sliding specimen platform or movement of the test media, capable of horizontal motion in a straight line of 30 mm ± 1 mm at a frequency of 60 cpm ± 5 cpm;

7.1.2 A rigid test head held perpendicular to the specimen platform that includes a 10 mm ± 1 mm square, rubber friction element, and applies a downward force of 10 N ± 0.5 N;

7.1.3 A means to hold the specimen firmly so that it does not slide during the test;

7.1.4 A counter to record the number of abrasion cycles.

7.2 *Abrasion Media,* steel wool, grade #0000.

7.3 *Contact Angle Meter, or Goniometer,* consisting of a controlled light source, a stage to hold the test specimen flat and horizontal, and a microscope or camera for viewing the droplet on the specimen as described in Test Method D7490; and a means for direct angle measurements.

7.3.1 Other designs are also acceptable, such as that described in Test Method D5946.

7.4 *Syringe,* or other dispensing equipment, capable of providing 2 µL droplet and suitable for use with water-like liquids.

8. Reagents and Materials

8.1 *Purity of Water*—Water meeting the requirements of Specification D1193 type IV, minimum, should be used for testing purposes.

9. Test Specimens

9.1 Apply the coating to a glass panel having both surfaces substantially plane and parallel. Prepare a minimum of one coated panel.

NOTE 4—Typical dimensions for a test panel are 5 cm × 10 cm to 7 cm × 14 cm.

9.2 The areas tested shall not contain visible blemishes, defects, fingerprints, or any other visible contamination. Clean specimens, as required, prior to testing using material and processes recommended by the coating manufacturer or agreed upon by the interested parties.

10. Preparation of Apparatus

10.1 To assist with specimen alignment during testing, a template of the abrasion path and droplet locations may be created as shown in Fig. 2. For transparent specimens coated on only one surface, the template may be traced on the opposite side of the surface to be tested with a permanent marker. For transparent specimens coated on both sides or for opaque specimens, the template may be indicated on a strip of masking tape loosely adhered to the test surface next to the area to be abraded.

10.2 Cut a strip of steel wool approximately 10 mm wide and 20 mm long in the strand orientation of the fibers. Fold the strip in half at the midpoint of the long axis to create a double layer pad. Compress the pad and trim any excess steel wool to obtain a pad 10 mm × 10 mm.

10.3 Adjust the abrader stroke length to 30 mm ± 1 mm and speed to a frequency of 60 cpm ± 5 cpm. Ensure the test head

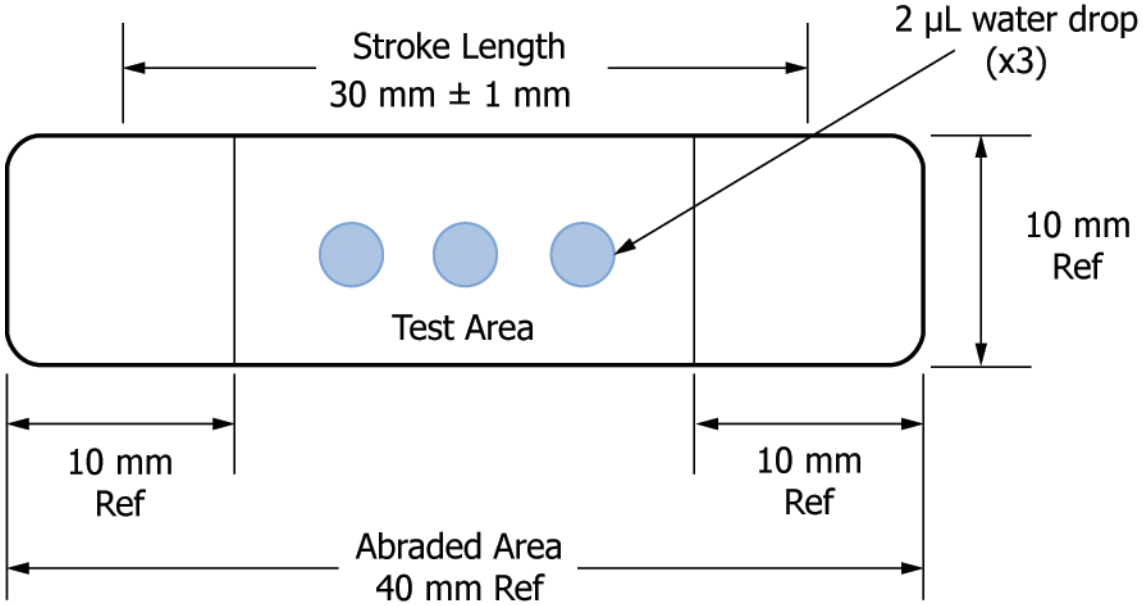

FIG. 2 Abrasion Path and Water Droplet Template (not to scale)

is perpendicular to the specimen platform when it is lowered onto the specimen surface and applies a downward force of 10 N ± 0.5 N.

11. Conditioning

11.1 *Conditioning*—Cure the coated panel under conditions of humidity and temperature as agreed upon between the interested parties.

11.2 *Test Conditions*—Special test conditions are not generally required for routine quality assurance or process control measurements.

11.3 *Test Conditions for Interlaboratory Studies*—Conduct tests in the standard laboratory atmosphere of 23 °C ± 2 °C and 50 % ± 5 % relative humidity, unless otherwise agreed upon by the interested parties.

12. Procedure

12.1 Gently wipe the surface of the test specimen with a lint free cloth to remove any dust or debris that may interfere with the contact angle measurement. Place one 2 µL droplet of type IV grade of reagent water on the centerline of the test area according to the droplet location template described in 10.1. Determine the initial contact angle. Repeat for two additional droplets.

NOTE 5—To avoid changes in angles as the water evaporates, measure the contact angle or record the image of the droplet within 30 s of depositing the drop.

NOTE 6—If the droplet interferes with measuring contact angle, it may be removed by wicking it with the corner of an absorbent laboratory wipe or cloth.

12.1.1 If the three initial contact angle measurements are significantly different, the specimen shall be rejected.

12.2 Secure the test specimen to the abrader and then place the steel wool pad under the test head with the fiber strand orientation being perpendicular to the direction of the stroke. Friction alone should be sufficient to hold the steel wool in place during testing.

NOTE 7—The abrasion path template may be used to help align the specimen under the test head.

12.3 Subject the coating to the number of abrasion cycles agreed upon by the interested parties. If not specified, test in intervals of 1000 abrasion cycles. The steel wool pad shall be replaced after every 2000 abrasion cycles.

12.4 At the completion of the test or after each abrasion cycle interval, remove the test specimen and measure the contact angle according to 12.1. Record the mean contact angle as $CA_{X\text{-}Cycles}$, where X represents the total number of abrasion cycles completed.

12.4.1 The test shall be stopped when the failure threshold, as defined by the interested parties, has been met. If the failure threshold has not been reached, repeat steps 12.2 to 12.4. If no failure threshold is specified, subject the test specimen until the mean contact angle is <100°. Report the number of abrasion cycles and mean contact angle measurement prior to the failure threshold.

NOTE 8—*Example*—A specimen with a threshold failure of <100° has a mean contact angle of 104° after 5000 abrasion cycles. After subjecting the specimen to an additional 1000 abrasion cycles the mean contact angle is 97°. Although the total number of accumulated abrasion cycles is 6000, the number of abrasion cycles that would be reported is 5000 with a contact angle of 104°.

13. Calculation

13.1 Calculate the mean contact angle measurement value at each specified test interval, as determined in 12.4.

14. Report

14.1 Report the following information for each test material: