Designation: D2578 – 17

Standard Test Method for Wetting Tension of Polyethylene and Polypropylene Films[1]

This standard is issued under the fixed designation D2578; 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 covers the measurement of the wetting tension of a polyethylene or polypropylene film surface in contact with drops of specific test solutions in the presence of air.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

NOTE 1—This test method and the specified reagents were specifically developed for polyethylene and polypropylene films. It is possible to utilize this test method and the specified reagents for films composed of other polymers, but this can affect the surface energies of the gas-liquid and solid-liquid interfaces, which will affect the contact angle and wetting tension. The applicability and significance for use of non-polyolefin materials must be established by the user.

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. Specific hazards statements are given in Section 8.*

NOTE 2—This test method is equivalent to ISO 8296.

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]

D618 Practice for Conditioning Plastics for Testing

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

2.2 *ISO Standard:*

ISO 8296 Plastics—Film and Sheeting—Determination of Wetting Tension[3]

3. Summary of Test Method

3.1 In this test method drops of a series of mixtures of formamide and ethyl Cellosolve[4] of gradually increasing surface tension are applied to the surface of the polyethylene or polypropylene film until a mixture is found that just wets the film surface. The wetting tension of the polyethylene or polypropylene film surface will be approximated by the surface tension of this particular mixture.

4. Significance and Use

4.1 When a drop of liquid rests on the surface of a solid, and a gas is in contact with both, the forces acting at the interfaces must balance. These forces can be represented by surface energies acting in the direction of the surfaces and it follows that:

$$\gamma GL\cos\theta = \gamma GS - \gamma SL \quad (1)$$

where:

θ = angle of contact of the edge of the drop with the solid surface,
γGL = surface energy of the gas - liquid interface,
γGS = surface energy of the gas - solid interface, and
γSL = surface energy of the solid - liquid interface.

4.1.1 The right side of the above equation (the difference between the surface energies of the gas - solid and solid - liquid interfaces) is defined as the wetting tension of the solid surface. It is not a fundamental property of the surface but depends on interaction between the solid and a particular environment.

4.1.2 When the gas is air saturated with vapors of the liquid, γGL will be the surface tension of the liquid. If the angle of contact is 0° the liquid is said to just wet the surface of the

[1] This test method is under the jurisdiction of ASTM Committee D20 on Plastics and is the direct responsibility of Subcommittee D20.19 on Film, Sheeting, and Molded Products.

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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.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[4] Registered trademark of Union Carbide Corp. for ethylene glycol monoethyl ether.

*A Summary of Changes section appears at the end of this standard

solid, and in this particular case (since cos θ = 1) the wetting tension of the solid will be equal to the surface tension of the liquid.

4.2 The ability of polyethylene and polypropylene films to retain inks, coatings, adhesives, etc., is primarily dependent upon the character of their surfaces, and can be improved by one of several surface-treating techniques. These same treating techniques have been found to increase the wetting tension of a polyethylene or a polypropylene film surface in contact with mixtures of formamide and ethyl Cellosolve in the presence of air. It is therefore possible to relate the wetting tension of a polyethylene or a polypropylene film surface to its ability to accept and retain inks, coatings, adhesives, etc. The measured wetting tension of a specific film surface can only be related to acceptable ink, coating, or adhesive retention through experience. Wetting tension in itself is not a completely acceptable measure of ink, coating, or adhesive adhesion.

NOTE 3—A wetting tension of 35 dynes/cm or higher has been generally found to reveal a degree of treatment normally regarded as acceptable for tubular film made from Type 1 polyethylene and intended for commercial flexographic printing. It is, however, possible that some other level of wetting tension may be required to indicate the acceptability of polyethylene films made by other processes, or from other types of polyethylene, or intended for other uses.

At the present date, insufficient experience has been gained to state a generally acceptable level of wetting tension for polypropylene films for commercial flexographic printing.

5. Interferences

5.1 Since the wetting tension of a polyethylene or polypropylene film in contact with a drop of liquid in the presence of air is a function of the surface energies of both the air - film and film - liquid interfaces, any trace of surface-active impurities in the liquid reagents or on the film may affect the results. It is, therefore, important that the portion of the film surface to be tested not be touched or rubbed, that all equipment be scrupulously clean, and that reagent purity be carefully guarded. Glass apparatus in particular is likely to be contaminated with detergents having very strong surface tension reducing ability unless specific precautions are taken to ensure their absence such as cleaning with chromic-sulfuric acid and rinsing with distilled water.

6. Apparatus

6.1 *Cotton-Tipped Wooden Applicators,* approximately 150 mm (6 in.) in length.

6.2 *Burets,* two, 50-mL.

6.3 *Bottles,* 100-mL, with caps and labels.

7. Reagents and Materials

7.1 Prepare mixtures of reagent grade formamide ($HCONH_2$) and reagent grade ethyl Cellosolve ($CH_3CH_2OCH_2CH_2OH$) in the proportions shown in Table 1 for the integral values of wetting tension in the range over which measurements are to be made. For extremely precise work, mixtures for determining fractional values of wetting tension may be made up by interpolating between the concentrations shown in Table 1.

TABLE 1 Concentration of Ethyl Cellosolve—Formamide Mixtures Used in Measuring Wetting Tension of Polyethylene and Polypropylene Films

Formamide, Volume %	Ethyl Cellosolve,[A] %	Wetting Tension,[B] dynes/cm
0	100.0	30
2.5	97.5	31
10.5	89.5	32
19.0	81.0	33
26.5	73.5	34
35.0	65.0	35
42.5	57.5	36
48.5	51.5	37
54.0	46.0	38
59.0	41.0	39
63.5	36.5	40
67.5	32.5	41
71.5	28.5	42
74.7	25.3	43
78.0	22.0	44
80.3	19.7	45
83.0	17.0	46
87.0	13.0	48
90.7	9.3	50
93.7	6.3	52
96.5	3.5	54
99.0	1.0	56

[A] Cellosolve is the registered trademark of Union Carbide Corp. for ethylene glycol monoethyl ether.
[B] Measured under conditions of 23 ± 2°C and 50 ± 5 % relative humidity.

NOTE 4—Although the mixtures of ethyl Cellosolve and formamide used in this test method are relatively stable, exposure to extremes of temperature or humidity should be avoided.

7.2 If desired, add to each of the formamide ethyl Cellosolve mixtures a very small amount of dye of high tinctorial value. The dye used should be of such color as to make drops or thin films of the solutions clearly visible on the surface of polyethylene or polypropylene film and must be of such chemical composition that it will not measurably affect the wetting tension of the solutions in the concentration used.[5]

7.3 Fully prepared mixtures of these reagents in varying concentrations are available from a number of commercial sources. Pens containing these mixtures are also commercially available. However, correlations between these options and freshly prepared solutions have not been established.

NOTE 5—Care must be taken when handling pens. Prolonged exposure to the atmosphere, temperature or humidity extremes, exposure to contaminants, or use beyond the stated expiration date will change their characteristics creating a potential for erroneous results.

8. Hazards

8.1 Formamide may cause skin irritation and is particularly dangerous in direct contact with the eyes. Safety goggles should be worn when making up new test mixtures.

8.2 Ethyl Cellosolve is a highly flammable solvent.

8.3 Both ethyl Cellosolve and formamide are toxic and pose exposure risks. Consult the applicable Safety Data Sheets

[5] "DuPont Victoria Pure Blue BO" at a maximum concentration of 0.03 % has been found satisfactory.