Designation: D 4001 – 93 (Reapproved 1999)

Standard Test Method for Determination of Weight-Average Molecular Weight of Polymers By Light Scattering[1]

This standard is issued under the fixed designation D 4001; 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 the test procedures for determining the weight-average molecular weight M_w of polymers by light scattering. It is applicable to all nonionic homopolymers (linear or branched) that dissolve completely without reaction or degradation to form stable solutions. Copolymers and polyelectrolytes are not within its scope. The procedure also allows the determination of the second virial coefficient, A_2, which is a measure of polymer-solvent interactions, and the root-mean-square radius of gyration $(s^2)^{1/2}$, which is a measure of the dimensions of the polymer chain.

1.2 The molecular-weight range for light scattering is, to some extent, determined by the size of the dissolved polymer molecules and the refractive indices of solvent and polymer. A range frequently stated is 10 000 to 10 000 000, but this may be extended in either direction with suitable systems and by the use of special techniques.

1.2.1 The lower limit to molecular weight results from low levels of excess solution scattering over that of the solvent. The greater the specific refractive increment d*n*/d *c* (difference in refractive indices of solution and solvent per unit concentration), the greater the level of solution scattering and the lower the molecular weight that can be determined with a given precision.

1.2.2 The upper limit to molecular weight results from the angular dependence of the solution scattering, which is determined by the molecular size. For sufficiently large molecules, measurements must be made at small scattering angles, which are ultimately outside the range of the photometer used.

1.3 The values stated in SI units are to be regarded as the standard.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.*

NOTE 1—There are no similar or equivalent ISO standards.

2. Referenced Documents

2.1 *ASTM Standards:*

E 380 Practice for Use of the International System of Units (SI)[2]

3. Terminology

3.1 *Definitions*—Units, symbols, and abbreviations are in accordance with Practice E 380.

4. Significance and Use

4.1 The weight-average molecular weight is a fundamental structure parameter of polymers, which is related to many physical properties of the bulk material, such as its rheological behavior. In addition, knowledge of the weight-average molecular weight, together with knowledge of the number-average molecular weight from osmometry, provides a useful measure of the breadth of the molecular-weight distribution.

4.2 Other important uses of information on the weight-average molecular weight are correlation with dilute-solution or melt-viscosity measurements and calibration of molecular-weight standards for use in liquid-exclusion (gel-permeation) chromatography.

4.3 To the extent that the light-scattering photometer is appropriately calibrated, light scattering is an absolute method and may therefore be applied to nonionic homopolymers that have not previously been synthesized or studied.

5. Apparatus

5.1 *Volumetric Flasks*, 100-mL, or other convenient size.

5.2 *Transfer Pipets*.

5.3 *Photometer*, whose major components, described in Appendix X1, are a light source, a projection optical system, a sample-cell area, a receiver optical system, a detector system, and a recording system. Typical photometers are described and summarized **(1)**[3] in the literature.

5.4 *Differential Refractometer*, with sensitivity of approximately 3×10^{-6} refractive-index units, capable of measuring the specific refractive increment d*n*/d*c* at the wavelength and temperature of the scattering measurements **(2).**

[1] This practice is under the jurisdiction of ASTM Committee D-20 on Plastics and is the direct responsibility of Subcommittee D20.70 on Analytical Methods (Section D20.70.05).

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[2] *Annual Book of ASTM Standards*, Vol 14.02.

[3] The boldface numbers in parentheses refer to the list of references at the end of this test method.

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