Designation: F 1635 – 95

Standard Test Method for In Vitro Degradation Testing of Poly (L-lactic Acid) Resin and Fabricated Form for Surgical Implants[1]

This standard is issued under the fixed designation F 1635; 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 poly(L-lactic acid) resin intended for use in surgical implants.

1.2 The requirements of this test method apply to poly(L-lactic acid) in various forms:

1.2.1 Virgin polymer, or

1.2.2 Any form fabricated from virgin polymer such as a semi-finished component of a finished product, a finished product, which may include packaged and sterilized implants, or a specially fabricated test specimen.

2. Referenced Documents

2.1 *ASTM Standards:*

D 638 Test Method for Tensile Properties of Plastics[2]

D 671 Test Method for Flexural Fatigue of Plastics by Constant-Amplitude-of-Force[2]

D 695 Test Method for Compressive Properties of Rigid Plastics[2]

D 747 Test Method for Apparent Bending Modulus of Plastics by Means of a Cantilever Beam[2]

D 790 Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials[2]

D 882 Test Method for Tensile Properties of Thin Plastic Sheeting[2]

D 1708 Test Method for Tensile Properties of Plastics by Use of Microtensile Specimens[2]

D 1822 Test Method for Tensile-Impact Energy to Break Plastics and Electrical Insulating Materials[2]

D 2857 Test Method for Dilute Solution Viscosity of Polymers[3]

F 1251 Terminology Relating to Polymeric Biomaterials in Medical and Surgical Devices[4]

3. Summary of Test Method

3.1 Samples of poly(L-lactic acid) resin, semi-finished components, finished surgical implants, or specially designed test specimens fabricated from poly(L-lactic acid) resin are placed in buffered saline solution at physiologic temperatures. Samples are periodically removed and tested for various material or mechanical properties at specified intervals (typically 1, 3, 6, 12, 26, 52 and 104 weeks).

4. Significance and Use

4.1 This test method is intended to help assess the biodegradation rates and changes in material or structural properties, or both, of poly(L-lactic acid) materials used in surgical implants.

4.2 This test method may not be appropriate for all types of implant applications. The user is cautioned to consider the appropriateness of the test method in view of the materials being tested and their potential application.

4.3 The application of mechanical loading or other forms of energy to the specimens during aging may significantly alter (that is, increase) the rate at which properties change. This needs to be considered when comparing in vitro behavior with that expected/observed at an in vivo site.

5. Apparatus

5.1 *Physiologic Soaking Solution*—A phosphate-buffered saline (PBS) solution shall be used. The pH of the solution shall be maintained at 7.4 ± 0.2 (see X1.3). The ionic concentration should be in the physiological range (for example, a solution that contains 0.1 M phosphate buffer and 0.1 M NaCl would be appropriate). The solution:specimen mass ratio shall be as high as practical. Although there is some experience with ratios as low as 20:1, the experimenter is cautioned that at lower ratios (that is, less buffering capacity) the solution pH may change more quickly. In accordance with 9.1.3 and X1.4, aging/testing is to be terminated once solution temperature or pH are allowed to drift outside of the specified ranges. Higher solution:specimen ratios (that is, 100:1) will facilitate maintenance of stable aging conditions.

5.1.1 Over the course of the study it may be possible to adjust solution pH and ionic concentration through the addition of individual solution constituents; however, it is preferable to exchange the test solution completely when it nears the limits of acceptability. Refer to X1.5 for additional information.

5.1.2 Other physiologic solutions, such as bovine serum, may be substituted provided the solution is properly buffered. An anti-microbial additive should be used to inhibit the growth

[1] This test method is under the jurisdiction of ASTM Committee F-4 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.15 on Material Test Methods.

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[2] *Annual Book of ASTM Standards*, Vol 08.01.

[3] *Annual Book of ASTM Standards*, Vol 08.02.

[4] *Annual Book of ASTM Standards*, Vol 13.01.

of microorganisms in the solution during the test period. Paragraph X1.6 provides additional information. The appropriate MSDS should always be consulted concerning toxicity, safe use, and disposal of such additives.

5.2 *Sample Container*—A self-contained, inert container (bottle, jar, vial, etc.) capable of holding the test sample and the required volume of physiologic soaking solution (see X1.7). Multiple samples may be stored in the same container provided that suitable sample separation is maintained to allow fluid access to each sample surface and to preclude sample-to-sample contact. Each container must be sealable against solution loss by evaporation.

5.3 *Constant Temperature Bath or Oven*—An aqueous bath or heated air oven capable of maintaining the samples and containers at physiologic temperatures, 37 ± 2°C, for the specified testing periods.

5.4 *pH Meter*—A pH metering device sensitive in the physiological range (pH 6 to pH 8).

5.5 *Balance*—A calibrated weighing device capable of measuring the weight of a sample to a precision of 0.1 % of its initial weight. A balance having precision to 0.05 % or 0.01 % will facilitate establishment of an appropriate specimen drying period.

5.6 *Other*—Additional equipment as deemed appropriate by the specific test method.

6. Sampling

6.1 *Weight Loss*—A minimum of three samples shall be tested per time period.

6.2 *Molecular Weight*—A minimum of three samples shall be tested per time period.

6.3 *Mechanical and Other Testing*—A minimum of three samples shall be tested per time period.

NOTE 1—Statistical significance may require more than the minimum number of samples to be tested.

6.4 *Solution Temperature and pH*—Soaking solutions shall be tested on a periodic basis throughout the test duration. The required test period is dependent on the solution:specimen mass ratio and the solution's buffering capacity; once per week is generally practical and suggested.

7. Sample and Test Specimen

7.1 All test samples shall be representative of the material under evaluation.

7.2 Samples for comparative tests shall be produced from the same material lot or batch and under the same fabricating conditions unless specifically noted.

8. Procedure

8.1 *Test A, Weight Loss*:

8.1.1 Test samples, in either resin or fabricated form, shall be weighed to a precision of 0.1 % of the total sample weight prior to placement in the physiological solution. Samples shall be dried to a constant weight before initial weighing (see Note 2 and Note X1.8). Drying conditions, including final relative humidity (if applicable), shall be reported and may include the use of a desiccator, partial vacuum or elevated temperatures (see Note 3).

8.1.2 Test samples shall be fully immersed in the physiological solution for a specified period of time (for example, 1 week, 2 weeks, etc.).

8.1.3 Upon completion of the specified time period, each sample shall be removed and dried to a constant weight (see Note 2 and Note X1.8). The weight shall be recorded to a precision of 0.1 % of the original total sample weight.

NOTE 2—Drying to a constant weight may be quantified as less than 0.1 % weight change over a period of 48 h, or less than 0.05 % change in 24 h if the balance used is capable of such precision. Paragraph X1.8 provides additional information.

NOTE 3—Elevated temperatures may be used to assist drying of the sample provided that the temperature used does not induce material or chemical changes in the sample. The drying conditions used for the samples prior to aging and for the samples retrieved at each test interval shall be identical. The actual drying conditions used are to be reported.

8.1.4 After weighing, the samples shall not be returned to the physiological solution and shall be retired from the study.

8.2 *Test B, Molecular Weight*:

8.2.1 Determine the inherent viscosity (logarithmic viscosity number) of representative samples in chloroform at 25°C using Test Method D 2857 prior to placement of samples in the physiological solution. Dilution ratio in g/mL shall be reported.

8.2.2 Test samples shall be fully immersed in the physiological solution for the specified period of time (for example, 1 week, 3 weeks, 52 weeks, etc.).

8.2.3 Samples shall be removed at each specified time period throughout the duration of the test, dried as in 8.1.1, and tested for inherent viscosity as above.

8.3 *Test C, Mechanical Testing*:

8.3.1 Determine the appropriate mechanical properties of representative samples of resin or fabricated forms using tensile, compressive, torque, bending or other appropriate mechanical tests prior to placement of the samples in the physiological solution (time zero). Relevant ASTM test methods may include one or more of the following:

Test Method D 638
Test Method D 671
Test Method D 695
Test Method D 747
Test Method D 790
Test Method D 882
Test Method D 1708
Test Method D 1822

8.3.2 Fully immerse test samples in the physiological solution at 37°C for the specified period of time (for example, 1 week, 2 weeks, etc.).

8.3.3 Remove samples at each specified time period throughout the duration of the test and retest using the originally selected mechanical test methods and conditions. Unless otherwise deemed relevant, samples should be tested in a non-dried or wet condition. Paragraph X1.9 provides additional information. Testing conditions, wet versus dry, testing temperature, etc., should be reported.

8.3.4 Unless specifically germane to the testing scheme, samples shall be retired after the completion of each test.

8.4 *Additional Testing*:

8.4.1 The characterization of other material properties and use of other test methods (that is, thermal properties measured