Designation: F 1185 – 03

Standard Specification for Composition of Hydroxylapatite for Surgical Implants[1]

This standard is issued under the fixed designation F 1185; 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 specification covers chemical and crystallographic requirements for hydroxylapatite intended for surgical implants. For a material to be called hydroxylapatite, it must conform to this specification. (See Appendix X1.)

1.2 The biological response to hydroxylapatite in soft tissue and bone has been characterized by a history of clinical use **(1-3)**[2] and by laboratory studies **(4-6)**.

1.3 This specification includes powder, particulate, and forms intended for use as surgical implants, components of surgical implants, or as raw materials for manufacturing processes such as thermal spray coating, electrophoretic deposition, physical vapor deposition, and so forth.

1.4 This specification specifically excludes hydroxylapatite coatings, amorphous calcium phosphate, ceramic-glasses, tribasic calcium phosphate, whitlockite, and alpha- and beta-tricalcium phosphate. (See Specification F 1088.)

2. Referenced Documents

2.1 *ASTM Standards:*

F 748 Practice for Selecting Generic Biological Test Methods for Materials and Devices[3]

F 981 Practice for Assessment of Compatibility of Biomaterials for Surgical Implants with Respect to Effect of Materials on Muscle and Bone[3]

F 1088 Specification for Beta-Tricalcium Phosphate for Surgical Implantation[3]

F 2024 Practice for X-Ray Diffraction Determination of Phase Content of Plasma-Sprayed Hydroxyapatite Coatings[3]

2.2 *Code of Federal Regulations:*[4]

Title 21, Part 820.

2.3 *National Formulary:*[5]

Tribasic Calcium Phosphate

2.4 *United States Pharmacopeia:*[6]

Identification Tests for Calcium and Phosphate <191>

Lead < 251>

Mercury <261>

Arsenic <211>

Heavy Metals <231> Method 1

2.5 *U. S. Geological Survey Method:*[7]

Cadmium

2.6 *American Society for Quality:*[8]

C1 Specification of General Requirements for a Quality Program

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

3.1.1 *hydroxylapatite*—the chemical substance having the empirical formula $Ca_5(PO_4)_3OH$.[9]

4. Chemical Requirements

4.1 Elemental analysis for calcium and phosphorus will be consistent with the expected stoichiometry of hydroxylapatite. The calcium and phosphorus contents shall be determined using a suitable method such as ion chromatography.

4.2 A quantitative X-ray diffraction analysis shall indicate a minimum hydroxylapatite content of 95 % as determined in accordance with Practice F 2024. Analysis of relative peak intensities shall be consistent with published data.[10]

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[1] This specification is under the jurisdiction of ASTM Committee F04 on Medical and Surgical Materials and Devices and is the direct responsibility of Subcommittee F04.13 on Ceramic Materials.

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[2] The boldface numbers in parentheses refer to the list of references at the end of this specification.

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

[4] Available from U.S. Government Printing Office, N. Capitol and H St., NW, Washington, DC 20402.

[5] National Formulary XVI. Available from U.S. Pharmacopeia Convention, Inc., 12601 Twinbrook Parkway, Rockville, MD 20852.

[6] United States Pharmacopeia XXI. Available from U.S. Pharmacopeia Convention, Inc., 12601 Twinbrook Parkway, Rockville, MD 20852.

[7] Crock, J. G., Felichte, F. E., and Briggs, P. H., "Determination of Elements in National Bureau of Standards Geological Reference Materials SRM 278 Obsidian and SRM 688 Basalt by Inductively Coupled Argon Plasma—Atomic Emission Spectrometry," *Geostandards Newsletter*, Vol 7, 1983, pp. 335-340.

[8] Available from American Society for Quality (ASQ), 600 N. Plankinton Ave., Milwaukee, WI 53203.

[9] Chemical Abstracts Service Registry Number [1306-06-5].

[10] The Joint Committee on Powdered Diffraction Standards has established a Powder Diffraction File. The Committee operates on an international basis and cooperates closely with the Data Commission of the International Union of Crystallography and ASTM (American Society for Testing and Materials). Hydroxylapatite data can be found on file card number 9-432 and is available from the Joint Committee on Powder Diffraction Standards, 1600 Park Lane, Swarthmore, PA 19081.

4.3 For hydroxylapatite derived from natural sources, the concentration of trace elements shall be limited as follows:

Element	ppm, max
As	3
Cd	5
Hg	5
Pb	30

Either inductively coupled plasma/mass spectroscopy (ICP/MS), atomic absorption (AAS), or the methods listed in 2.4 and 2.5 shall be used.

4.3.1 The analysis of other trace elements may be required, based on the conditions, apparatus, or environments specific to the manufacturing techniques and raw materials.

4.4 The maximum allowable limit of all heavy metals determined as lead will be 50 ppm as described in 2.4 or equivalent. Sample preparation will be identical to that for tribasic calcium phosphate as specified in the National Formulary (2.3) except that approximately 1 g of material will be dissolved in approximately 30 mL of 5 % HCl and boiled.

4.5 It is recommended that all metals or oxides not detected as lead present in concentrations equal to or greater than 0.1 % be listed on the package insert.

5. Biocompatibility

5.1 Before any new device is used clinically, the tissue response should be characterized by the methods recommended in Practices F 748 and F 981 as appropriate.

6. Test Specimen Fabrication

6.1 Prepare test specimens from the same batch of material and by the same processes as those employed in fabricating the ceramic implant device.

7. Quality Program Requirements

7.1 The manufacturer shall conform to Good Manufacturing Practices (2.2) or its equivalent.

7.2 The manufacturer shall maintain a quality program, such as the program defined in ASQ C1 (2.6) or equivalent.

8. Keywords

8.1 bioceramic; bone graft; hydroxylapatite (HA); hydroxyapatite; tricalcium phosphate (TCP); whitlockite

APPENDIXES

(Nonmandatory Information)

X1. RATIONALE

X1.1 Hydroxylapatite is commercially available as a synthetic bone-grafting material. As with any implant material, the bioresponse is critically dependent upon the material properties. To achieve reliable biocompatibility these must be known and consistent. This material standard provides specifications for a biocompatible grade of hydroxylapatite. Trace element content and physical form must be within established biocompatibility standards.

X1.2 It is recognized that a separate performance standard may be necessary for each end-use product. For this reason, physical and mechanical properties were not specified. A source of general test methods for ceramics may be found in Ref **(7)**.

X2. BIOCOMPATIBILITY

X2.1 No known surgical implant material has ever been shown to be completely free of adverse reactions in the human body. However, long-term clinical experience has shown that an acceptable level of biological response can be expected if the materials are used in appropriate applications.

REFERENCES

(**1**) Cranin, A. N., Tobin, G., Gelbman, J., Varjan, R., "A Seven Year Follow-up of Patients with (H/A) Ridge Augmentation," *Transactions of the Society for Biomaterials*, 1986, p. 155.

(**2**) Kent, J. N., Quinn, J. H., Zide, M. F., Guerra, L. R., Boyne, P., "Augmentation of Deficient Alveolar Ridges with Nonresorbable Hydroxylapatite or with Autogenous Cancellous Bone," *Journal of Oral and Maxillofacial Surgery*, Vol 41 (10), 1983, pp. 629-642.

(**3**) Yukna, R. A., Mayer, E. T., Brite, D. V., "Longitudinal Evaluation of Durapatite Ceramic as an Alloplastic Implant in Periodontal Osseous Defects After Three Years," *Journal of Periodontology*, Vol 55 (11), 1984, pp. 633-637.

(**4**) Jarcho, M., Kay, J. F., Gumaer, K. I., Doremus, R. H., and Drobeck, H. P., "Tissue, Cellular and Subcellular Events at a Bone-Ceramic Hydroxylapatite Interface," *Journal of Bioengineering*, Vol 1, 1977, pp. 79-92.

(**5**) Drobeck, H. P., Rothstein, S. S., Gumaer, K. I., Sherer, A. D., and Slighter, R. G., "Histologic Observation of Soft Tissue Responses to Implanted, Multifaceted Particles and Discs of Hydroxylapatite," *Journal of Oral and Maxillofacial Surgery*, Vol 42, 1984, pp. 143-149.

(**6**) Tracy, B. M. and Doremus, R. H., "Direct Electron Microscopy Studies of the Bone-Hydroxylapatite Interface," *Journal of Biomedical Materials Research*, Vol 18, 1984, pp. 719-726.

(**7**) *Annual Book of ASTM Standards*, Vol 15.02.