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## Protamine Sulfate

### DEFINITION

Protamine Sulfate is a purified mixture of peptides obtained from the sperm or testes of Salmonidae, which has the property of neutralizing heparin. Each mg of Protamine Sulfate, calculated on the dried basis, neutralizes NLT 100 USP Heparin Units. It contains NLT 90.0% and NMT 110.0% of protamine sulfate, calculated on the dried basis.

### IDENTIFICATION

- **A.** The retention times of the four major peaks of the *Sample solution* correspond to those of the *Standard solution*, as obtained in the Assay.
- **B. IDENTIFICATION TESTS—GENERAL (191), Sulfate:** Meets the requirements
- **C. BIODENTITY**

**Sample solution A:** 0.15 mg/mL of Protamine Sulfate in water

**Sample solution B:** Dilute 2.0 mL of *Sample solution A* with water to 3.0 mL.

**Sample solution C:** Dilute 1.0 mL of *Sample solution A* with water to 3.0 mL.

**Titrant:** [USP Heparin Sodium for Assays RS](#) in water (about 80–120 USP Heparin Units/mL)

**Analysis:** [NOTE—Titrate each *Sample solution* in duplicate.] Transfer a volume of each *Sample solution* to the analytical cell of a suitable colorimeter, and set the apparatus for measurement at a suitable wavelength (none is critical) in the visible range. Add *Titrant* in small volumes until there is a sharp increase in the absorbance, and note the volume of *Titrant* added. Perform the entire *Analysis* in triplicate for a total of 18 determinations.

Calculate the number of USP Heparin Units per mg of Protamine Sulfate in the volume of *Titrant* added at the endpoint.

Calculate the USP Heparin Units neutralized per mg of Protamine Sulfate taken:

$$\text{Result} = (V_T \times C_T) / (V_S \times C_U)$$

$V_T$  = volume of *Titrant* added (mL)

$C_T$  = concentration of *Titrant* (USP Heparin Units/mL)

$V_S$  = volume of each *Sample solution* (mL)

$C_U$  = concentration of Protamine Sulfate in each *Sample solution* (mg/mL)

Calculate the potency of the Protamine Sulfate as the average of the 18 values. Calculate the three standard deviations for the results obtained with each *Sample solution*. Calculate the three standard deviations for the results obtained with each of the three independent assays. The test is valid if each of the six standard deviations is NMT 5% of the average result.

**Acceptance criteria:** Each mg of Protamine Sulfate neutralizes NLT 100 USP Heparin Units on the dried basis.

### ASSAY

- **PROCEDURE**

**Solution A:** 0.1 M monobasic sodium phosphate. Adjust with phosphoric acid to a pH of 1.8. Pass through a membrane filter of 0.45- $\mu\text{m}$  pore size, and degas before use.

**Solution B:** *Solution A* and acetonitrile (93.5:6.5)

**Mobile phase:** See [Table 1](#).

**Table 1**

Time (min)	Solution A (%)	Solution B (%)
0	85	15
15	55	45
25	55	45
30	85	15

[**NOTE**—Initial gradient composition may be adjusted as appropriate to obtain sufficient resolution. The end of the gradient can be increased to re-equilibrate the column for the next injection.]

**Standard solution:** 0.5 mg/mL of [USP Protamine Sulfate RS](#) in 0.01 M hydrochloric acid

**Sample solution:** 0.5 mg/mL of Protamine Sulfate in 0.01 M hydrochloric acid

#### Chromatographic system

(See [Chromatography \(621\), System Suitability](#).)

**Mode:** LC

**Detector:** UV 214 nm

**Column:** 4.6-mm × 25-cm; 5-μm packing L1

**Column temperature:** 55°

**Flow rate:** 1 mL/min

**Injection volume:** 100 μL

#### System suitability

**Sample:** Standard solution

#### Suitability requirements

**Retention time:** The chromatogram of the *Standard solution* must show four major peaks (in increasing elution order: protamine peptides 1, 2, 3, and 4) with protamine peptide 4 eluting no later than 15 min. [**NOTE**—See the reference chromatogram provided with the [USP Protamine Sulfate RS](#) certificate.]

**Resolution:** NLT 2.0 between protamine peptides 1 and 2, calculated by the tangent method

**Relative standard deviation:** NMT 2.0% for the total integrated areas of at least six replicate injections, using vertical drop down integration

#### Analysis

**Samples:** Standard solution and Sample solution

Separately inject equal volumes of the *Standard solution* (at least six injections) and the *Sample solution*, record the chromatograms for approximately 30 min, and measure the responses for all the peaks using a full scale comparable to the height of the largest peak and using vertical drop down integration.

Calculate the percentage of protamine sulfate in the portion of Protamine Sulfate taken:

$$\text{Result} = \Sigma[(r_U/r_S) \times (C_S/C_U)] \times 100$$

$r_U$  = peak response from the *Sample solution*

$r_S$  = peak response from the *Standard solution*

$C_S$  = concentration of [USP Protamine Sulfate RS](#) in the *Standard solution* (mg/mL)

$C_U$  = concentration of Protamine Sulfate in the *Sample solution* (mg/mL)

**Acceptance criteria:** 90.0%–110.0% on the dried basis

#### IMPURITIES

- [RESIDUAL SOLVENTS \(467\)](#): Meets the requirements

- **CHROMATOGRAPHIC PURITY**

**Solution A, Solution B, Mobile phase, Standard solution, Sample solution, Chromatographic system, and System suitability:** Proceed as directed in the Assay.

#### Analysis

**Sample:** Sample solution

Proceed as directed in the Assay.

Calculate the percentage purity of Protamine Sulfate from the four protamine peptide peaks:

$$\text{Result} = [(r_{U_1} + r_{U_2} + r_{U_3} + r_{U_4})/r_T] \times 100$$

$r_{U_1}$  = peak response of protamine peptide 1 from the *Sample solution*

$r_{U_2}$  = peak response of protamine peptide 2 from the *Sample solution*

$r_{U_3}$  = peak response of protamine peptide 3 from the *Sample solution*

$r_{U_4}$  = peak response of protamine peptide 4 from the *Sample solution*

$r_T$  = sum of all the peak responses from the *Sample solution*

**Acceptance criteria:** NLT 92%

**Change to read:**

- **IRON (241), Procedures, Procedure 1** ▲ (CN 1-JUN-2023) : NMT 10 ppm
- **METHYLMERCURY**: NMT 10 ppm, using a validated analytical procedure. [NOTE—Methylmercury determination is not necessary when the content for total mercury is less than the limit for methylmercury.]

#### SPECIFIC TESTS

- **BACTERIAL ENDOTOXINS TEST (85)**: NMT 7.0 USP Endotoxin Units/mg

- **LOSS ON DRYING (731)**

**Analysis:** Dry at 105° for 3 h.

**Acceptance criteria:** NMT 5%

- **ULTRAVIOLET ABSORBANCE**

**Sample solution:** 1.0% Solution of Protamine Sulfate in water

#### Instrumental conditions

**Mode:** UV

**Wavelength range:** 260–280 nm

**Blank:** Water

**Acceptance criteria:** The difference between the absorbance of the *Sample solution* at 260–280 nm and the *Blank* is NMT 0.1.

- **SULFATE**

**Sample:** 150 mg

**Analysis:** Dissolve the *Sample* in 75 mL of water, add 5 mL of 3 N hydrochloric acid, heat to boiling, and while maintaining the boiling point, slowly add 10 mL of barium chloride TS. Cover the vessel, and allow the mixture to stand on a steam bath for 1 h. Filter, wash the precipitate with several portions of hot water, dry, and ignite to constant weight. The weight of the barium sulfate, multiplied by 0.4117, represents the weight of sulfate in the portion of Protamine Sulfate taken.

**Acceptance criteria:** 16%–22% on the dried basis

#### ADDITIONAL REQUIREMENTS

- **PACKAGING AND STORAGE:** Preserve in tight and tamper-proof containers. Store at controlled room temperature or at 2°–8°.

- **USP REFERENCE STANDARDS (11)**

[USP Endotoxin RS](#)

[USP Heparin Sodium for Assays RS](#)

[USP Protamine Sulfate RS](#)

**Auxiliary Information** - Please [check for your question in the FAQs](#) before contacting USP.

Topic/Question	Contact	Expert Committee
PROTAMINE SULFATE	<a href="#">Jennifer Tong Sun</a> Senior Scientist II	BIO32020 Biologics Monographs 3 - Complex Biologics and Vaccines
REFERENCE STANDARD SUPPORT	RS Technical Services <a href="mailto:RSTECH@usp.org">RSTECH@usp.org</a>	BIO32020 Biologics Monographs 3 - Complex Biologics and Vaccines

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