ARTESUNATE:

Final text for revision of *The International Pharmacopoeia*  
(December 2009)

This monograph was adopted at the Forty-fourth WHO Expert Committee on Specifications for Pharmaceutical Preparations in October 2009 for revision of the text published in the 4th Edition of the International Pharmacopoeia

**ARTESUNATUM**

**ARTESUNATE**

[Note from Secretariat:]
- Changes from the current monograph are indicated in the text by *insert* or *delete*
- It is intended to further revise this monograph in order to include requirements for Artesunate API to be used for parenteral preparations.

The following sections of the monograph will therefore be revised:
- Storage
- Labelling

and the following tests will be added:
- Bacterial endotoxins
- Sterility

![Chemical structure of Artesunate](image)

C_{19}H_{28}O_8

**Relative molecular mass.** 384.4

**Chemical name.** (3R,5aS,6R,8aS,9R,10S,12R,12aR)-Decahydro-3,6,9-trimethyl-3,12-epoxy-12H-pyrano[4,3-j]-1,2-benzodioxepin-10-ol, hydrogen succinate; CAS Reg. No. 182824-33-5.
Description. A fine, white crystalline powder.

Solubility. Very slightly soluble in water; very soluble in dichloromethane R; freely soluble in ethanol (~750 g/l) TS and acetone R.

Category. Antimalarial.

Storage. Artesunate should be kept in a well-closed container and protected from light.

Requirements

Definition. Artesunate contains not less than 96.0% and not more than the equivalent of 102.0% of artesunate (C_{19}H_{28}O_{8}) using Assay method A, and not less than 99.0%-98.0% and not more than the equivalent of 101.0%-102.0% of artesunate (C_{19}H_{28}O_{8}) using Assay method B, both calculated with reference to the anhydrous substance.

Identity tests

- Either test A alone or tests B, C, and D may be applied.

A. Carry out the examination as described under 1.7 Spectrophotometry in the infrared region. The infrared absorption spectrum is concordant with the spectrum obtained from artesunate RS or with the reference spectrum of artesunate.

B. Carry out the test as described under 1.14.1 Thin-layer chromatography, using silica gel R6-R5 as the coating substance and a mixture of 70 volumes of ethanol R, 30 volumes of toluene R and 1.5 volumes of ammonia (~260 g/l) TS 5 volumes of ethyl acetate R and 95 volumes of toluene R as the mobile phase. Apply separately to the plate 2 µl of the following two solutions in toluene Rmethanol R. For solution (A) use 0.401.0 mg of the test substance per ml. For solution (B) use 0.401.0 mg of artesunate RS per ml. After removing the plate from the chromatographic chamber, allow it to dry in air or in a current of cool air. Spray with anisaldehyde/methanol TS and heat the plate to 120°C for 5 minutes. Examine the chromatogram in ultraviolet light (254 nm)daylight.

The principal spot obtained with solution A corresponds in position, appearance, and intensity with that obtained with solution B.

C. Dissolve 0.1 g of Artesunate in 40 ml of dehydrated ethanol R, shake, and filter. To half of the filtrate (keep the remaining filtrate for test D) add about 0.5 ml of hydroxylamine hydrochloride TS2 and 0.25 ml of sodium hydroxide (~80 g/l) TS. Heat
the mixture in a water-bath to boiling, cool, add 2 drops of hydrochloric acid (~70 g/l) TS and 2 drops of ferric chloride (50 g/l) TS; a light red-violet colour is produced.

D. Evaporate the remaining filtrate from test C on a water-bath to a volume of about 5 ml. Place a few drops of the mixture on a white porcelain dish, add one drop of vanillin/sulfuric acid TS1; a reddish-brown colour is produced.

**Melting range.** 132–135°C.

**Specific optical rotation.** Use a 10 mg/ml solution in dichloromethane R and calculate with reference to the anhydrous substance:

\[
[\alpha]_{D}^{20} = +4.5^\circ \text{to } +6.5^\circ
\]

**Heavy metals.** Use 1.0 g for the preparation of the test solution as described under 2.2.3 Limit test for heavy metals, Procedure 3; determine the heavy metals content according to Method A; not more than 20 µg/g.

**Sulfated ash.** (2.3) Not more than 1.0 mg/g.

**Water.** Determine as described under 2.8 Determination of water by the Karl Fischer method, Method A, using 2 g of the test substance; the water content is not more than 5 mg/g.

**pH value.** (1.13) pH of a 10 mg/g aqueous suspension, 3.5 - 4.5.

**Related substances**

Carry out the test as described under 1.14.4 High-performance liquid chromatography, using the conditions given below under Assay method A.

Use solutions (1) and (3) as described under Assay method A. For solution (4) dilute 1 ml of solution (1) to 100 ml with acetonitrile R.

Inject separately 20 µl each of solutions (1), (3) and (4). Record the chromatograms for about 4 times the retention time of artemunate. In the chromatogram obtained with solution (3), the following peaks are eluted at the following relative retention with reference to artemunate (retention time about 9 minutes): α-artenimol about 0.58, β-artenimol about 0.91 and impurity B (artemisinin) about 1.30. The test is not valid unless the peak-to-valley ratio (Hp/Hv) is at least 5.0, where Hp = height above the baseline of the peak due to β-artenimol and Hv = height above the baseline of the lowest point of the curve separating this peak from
the peak due to artesunate. The chromatogram obtained with solution (1) may show a peak due to impurity C eluting at a relative retention of about 2.7 with reference to artesunate.

In the chromatogram obtained with solution (1):

– the combined areas of any peaks corresponding to α-artenimol and β-artenimol (impurity A) are not greater than the area of the principal peak obtained with solution (4) (1.0%);

– the area of any peak corresponding to impurity B (artemisinin) is not greater than 0.5 times the area of the principal peak obtained with solution (4) (0.5%);

– the area of any peak corresponding to impurity C, when multiplied by a correction factor of 0.07, is not greater than 0.2 times the area of the principal peak obtained with solution (4) (0.2%);

– the area of any other peak, other than the principal peak, is not greater than 0.2 times the area of the principal peak in the chromatogram obtained with solution (4) (0.2%);

– The sum of the corrected area of any peak corresponding to impurity C and the areas of all other peaks, other than the principal peak, is not greater than twice the area of the principal peak obtained with solution (4) (2.0%). Disregard any peak with an area less than 0.05 times the area of the principal peak in the chromatogram obtained with solution (4) (0.05%).

• Either test A or test B may be applied.

A. Carry out the test as described under 1.14.4 High-performance liquid chromatography, using the conditions given below under Assay method A.

Inject alternately 20µl each of solutions A and C.

Measure the areas of the peak responses obtained in the chromatograms from solutions A and C, and calculate the content of the related substances as a percentage. In the chromatogram obtained with solution A, the area of any peak, other than the principal peak, is not greater than that obtained with solution C (1.0%). Not more than one peak is greater than half the area of the principal peak obtained with solution C (0.5%). The sum of the areas of all peaks, other than the principal peak, is not greater than twice the area of the principal peak obtained with solution C (2.0%). Disregard any peak with an area less than 0.1 times the area of the principal peak in the chromatogram obtained with solution C.
B. Carry out the test as described under 1.14.1 Thin-layer chromatography, using silica gel R1 as the coating substance and a mixture of 48 volumes of light petroleum R1, 36 volumes of ethyl acetate R and 1 volume of glacial acetic acid R as the mobile phase. Apply separately to the plate 10 µl of each of the following 3 solutions in dichloromethane R containing (A) 5.0 mg of Artesunate per ml, (B) 0.05 mg of Artesunate per ml, and (C) 0.025 mg of Artesunate per ml. After removing the plate from the chromatographic chamber, allow it to dry in air, and spray with vanillin/ sulfuric acid TS. Examine the chromatogram in daylight.

Any spot obtained with solution A, other than the principal spot, is not more intense than that obtained with solution B (1.0%). Furthermore, not more than one such spot is more intense than that obtained with solution C (0.5%).

Assay

• Either method A or method B may be applied.

A. Determine by 1.14.4 High-performance liquid chromatography, using a stainless steel column (12.5 cm × 3.5 mm) packed with particles of silica gel, the surface of which has been modified with chemically bonded octadecylsilyl groups (5 µm). As the mobile phase, use a mixture of equal volumes of acetonitrile R and buffer pH 3.0 (dissolve 1.36 g of potassium dihydrogen phosphate R in 1000 ml of water and adjust the pH to 3.0 with phosphoric acid (~1440 g/l) TS).

Prepare the following solutions in acetonitrile R: solution (A) 4.0 mg of Artesunate per ml; solution (B) 4.0 mg of artesunate RS per ml; and for solution (C) dilute solution A to obtain a concentration equivalent to 0.04 mg of Artesunate per ml.

Operate with a flow rate of 0.6 ml per minute. Maintain the column temperature at 30 °C and use an ultraviolet spectrophotometer set at a wavelength of about 216 nm.

Inject alternately 20 µl each of solutions A and B.

Measure the areas of the peak responses obtained in the chromatograms from solutions A and B, and calculate the percentage content of C_{19}H_{28}O_{8} with reference to the anhydrous substance.

A. Carry out the test as described under 1.14.4 High-performance liquid chromatography, using a stainless steel column (10 cm × 4.6 mm) packed with particles of silica gel, the surface of which has been modified with chemically bonded octadecylsilyl groups (3
µm). As the mobile phase, use a mixture of 44 volumes of acetonitrile R and 56 volumes of buffer pH 3.0.

Prepare the buffer pH 3.0 by dissolving 1.36 g of potassium dihydrogen phosphate R in 900 ml of water R, adjust the pH to 3.0 with phosphoric acid (~1440 g/l) TS and dilute to 1000 ml with water R.

Prepare the following solutions in acetonitrile R. For solution (1) dissolve 40 mg of the test substance, accurately weighed, and dilute to 10 ml. For solution (2) dissolve 40 mg of artemisate RS, accurately weighed, and dilute to 10 ml. For solution (3) dissolve about 1 mg of arteminol RS, about 1 mg of artemisinin RS and about 10 mg of artemisate RS in 10 ml.

Operate with a flow rate of 1.0 ml per minute. Maintain the column temperature at 30°C and use as detector an ultraviolet spectrophotometer set at a wavelength of about 216 nm.

Inject separately 20 µl each of solutions (1), (2) and (3). Record the chromatograms for about 4 times the retention time of artemisate. In the chromatogram obtained with solution (3), the following peaks are eluted at the following relative retention with reference to artemisate (retention time about 9 minutes): α-artenimol about 0.58, β-artenimol about 0.91 and impurity B (artemisinin) about 1.30. The assay is not valid unless the peak-to-valley ratio (Hp/Hv) is at least 5.0, where Hp = height above the baseline of the peak due to β-artenimol and Hv = height above the baseline of the lowest point of the curve separating this peak from the peak due to artemisate. The chromatogram obtained with solution (1) may show a peak due to impurity C eluting at a relative retention of about 2.7 with reference to artemisate.

Measure the areas of the peak responses obtained in the chromatograms from solutions (1) and (2), and calculate the percentage content of artemisate (C₁₉H₂₈O₈) with reference to the anhydrous substance.

B. Dissolve about 0.25 g of Artesunate, accurately weighed, in 25 ml of neutralized ethanol TS and titrate with sodium hydroxide (0.05 mol/l) VS, using 2 drops of phenolphthalein/ethanol TS as indicator.

Each ml of sodium hydroxide (0.05 mol/l) VS is equivalent to 19.22 mg of C₁₉H₂₈O₈.

¹ Luna® has been found suitable.
Impurities

The following list of known and potential impurities that have been shown to be controlled by the tests in this monograph is given for information.

A. Artenimol (the $\alpha$ and $\beta$-forms are in slow equilibrium in solution)

B. Artemisinin

C. (3R,5aS,6R,8aS, 12R,12aR)-Octahydro-3,6,9-trimethyl-3,12-epoxy-12H-pyrano[4,3-j]-1,2-benzodioxepine; 9,10-Didehydro-10-deoxyartemisinin (Glycan)

[Note from Secretariat: Systematic name of impurity C to be confirmed.]