ASYMMETRIC EPOXIDATION OF A QUINONE AND SYNTHESSES OF CHIRAL LACTONES

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Abstract -- The epoxy diketone (2) is obtained in optically active form by the phase-transfer chiral epoxidation of the quinone (1). The transformation of 2 to the lactones (5) and (6) is carried out without the loss of optical activity.

The asymmetric epoxidation of enones under phase-transfer conditions in the presence of chiral cation salts as catalysts has been reported. In connection with the syntheses of benzo[c/phenanthridines, we have investigated the asymmetric epoxidation of the quinone (1) to the chiral epoxy diketone (2), and the syntheses of the chiral lactones (5) and (6) from 2.

tert-Butyl hydroperoxide (75%, 0.4 ml) was added to a stirred mixture of 1 (101 mg), 1-benzylquininium chloride (BQC) (2.6 mg) and powdered sodium hydroxide (27 mg) in toluene (10 ml) with cooling. The mixture was vigorously stirred at 0°C for 30 min and then at room temperature for 1 h. Work-up of the reaction mixture and preparative thin-layer chromatography (silica gel; benzene/ethyl acetate=20/1, v/v) gave the crude (1+)-2 (101 mg, 95%, 78% ee) as light yellow crystals of mp 135-137° with \( \alpha/23^\circ \) = +9.2°, \( \alpha/22^\circ \) = +12.5°, \( \alpha/22^\circ \) = +20.0° and \( \alpha/22^\circ \) = +175.1° (c=1.0, dioxane). Its recrystallization from ethanol furnished (+)-2 (66 mg, 100% ee) as colorless prisms of mp 140-141.5° with \( \alpha/24^\circ \) = +10.5°, \( \alpha/24^\circ \) = +13.3°, \( \alpha/24^\circ \) = +22.0° and \( \alpha/24^\circ \) = +200.3° (c=1.3, dioxane).

Reduction of (+)-2 with sodium borohydride at -50°C for 1 h afforded the (-)-epoxy ketones (3) (76%), \( \alpha/22^\circ \) = -52.0° (c=0.1, chloroform) and (4) (23%), \( \alpha/22^\circ \) = -136.3° (c=0.3, chloroform). The ir spectra showed intramolecular hydrogen-bondings at 3520 (OH=O) and 3587 cm\(^{-1}\) (OH=H) for (-)-3 and (-)-4, respectively. The configurations of the 4-hydroxyl groups in (-)-2 and (-)-4 are established to be cis and trans with respect to the oxirane rings, respectively, on the basis of these ir data.

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Chart 1

a) tert-BuOOH/NaOH/BQC/toluene
b) NaBH₄/MeOH
c) Al₂O₃/MeOH-CHCl₃
Further reduction of (-)-2 with sodium borohydride gave the cis-(-)-lactone (5) (44%), $\delta_{\text{Me, 2}}^{389}$ -217.8° (c=0.2, chloroform), trans-(-)-lactone (6) (1%), $\delta_{\text{Me, 2}}^{20}$ -104.0° (c=0.1, chloroform) and cis-(-)-diol (7) (38%), $\delta_{\text{Me, 2}}^{23}$ +161.4° (c=0.3, chloroform). From this result, it can be seen that the 12-hydroxyl groups in (-)-5 and (-)-6, and the 4-hydroxyl group in (+)-2 have the same configuration as that of the 4-hydroxyl group in (-)-2. The cis steroidal conformation of the B/C ring fusion in (-)-2 is determined on the basis of the presence of a W-path coupling between the 4b-proton (δ 5.76, d, J 1 Hz) and 11-proton (δ 3.58, dd, J 3 and 1 Hz) in the nmr spectrum.

Alumina-induced lactonization of (+)-2 afforded (-)-6 (74%) which showed a characteristic signal for the 4-proton at δ 7.91 (dd, J 8 and 2 Hz) (5: δ 7.36) in the nmr spectrum owing to interaction of the 4b-O(5) bond. The optical purities (100%) of (-)-5 and (-)-6 were confirmed by the nmr spectra using tris-(3-(heptafluoropropylhydroxymethylene)-d-camphorato/europium(III).

The syntheses of chiral benzo/c/phenanthridines (8) are now in progress.

REFERENCES AND NOTES


2. The structures of all compounds obtained were supported by the ir, nmr and mass spectra.


7. The word "crude" means a mixture of enantiomers in unequal amounts.

8. The enantiomeric excess (ee) was determined by the nmr spectrum using Eu(hfc)$_3$.


Received, 19th May, 1980