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THIO-CLAISEN REARRANGEMENT OF ALLYL 3-QUINOLYL SULFIDES

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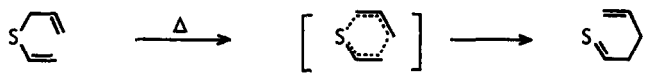
Recently, we reported the thio-Claisen rearrangement of allyl 4-quinolyl sulfides, proceeding through the [3,3] sigmatropic rearrangement of the sulfides to 3-allyl-4(1H)-quinolinethiones followed by their prototropic cyclization to give 2,3-dihydrothieno[3,2-c]quinolines (1,2), and the reversible [3,3] sigmatropic rearrangements between allyl 2-quinolyl sulfides and N-allylthiocarbostyrils (3). We now wish to report on the thermal rearrangement of allyl 3-quinolyl sulfides as an extension of our studies on the [3,3] sigmatropic rearrangements of aromatic allyl sulfides.

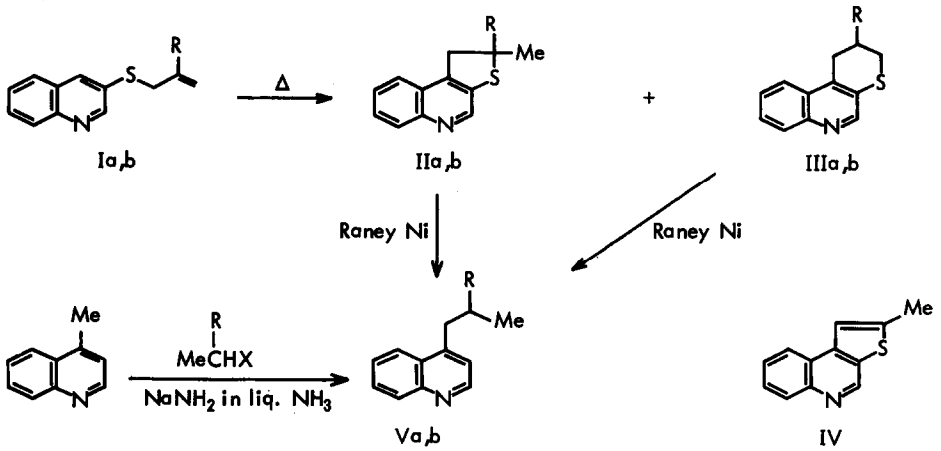


Allyl 3-quinolyl sulfide (Ia), oil; picrate, m.p. 187-187.5°, was prepared by alkylation of sodium 3-quinolylmercaptide with allyl bromide at room temperature under argon stream in 90% yield. Similarly, methallyl 3-quinolyl sulfide (Ib), oil; picrate, m.p. 147-148°, was obtained in 95% yield.

When the allyl sulfide Ia in dimethylaniline was heated at 200° for 2 hr under argon stream, two kinds of cyclization products, 2-methyl-1,2-dihydrothieno[2,3-c]quinoline (IIa), b.$p_{0.25}$ 135-138°; picrate, m.p. 223-224°, and 2,3-dihydro-1H-thiopyrano[2,3-c]quinoline (IIIa), oil; picrate, m.p. 220-222°, were obtained in 66.6 and 15% yields, respectively. Neat rearrangement of Ia at 200° for 1 hr under argon stream afforded 9.4% of 2-methylthieno[2,3-c]quinoline (IV), oil; picrate, m.p. 254-255°, in addition to 73.5% of IIa and 6.4% of IIIa. The NMR spectrum of IIa exhibited methyl (τ 8.50, 3H-doublet, J = 6.5 Hz), methylene (τ 6.79, 1H-quartet, J = 16.0, 6.5 Hz, and τ 6.29, 1H-quartet, J = 16.0, 7.8 Hz), methine (τ 5.84, 1H-multiplet), and C-4 aromatic (τ 1.25, 1H-singlet) proton signals and that of IIIa showed C-2 methylene (τ 7.5-7.9, 2H-multiplet), C-1 and C-3 methylene (τ 6.75-7.0, 4H-multiplet), and C-5 aromatic (τ 1.47, 1H-singlet) proton signals. Desulfurization of IIa and IIIa with Raney nickel W-2 in ethanol gave

an identical product, $C_{12}H_{13}N$, oil; picrate, m.p. 209-210°, which was identical with 4-propylquinoline (Va) (4) prepared by the alkylation of sodium salt of lepidine with ethyl iodide in liquid ammonia. IV, having the proton signals at τ 7.31 (3H-doublet, J = 1.3 Hz), 0.84 (1H-singlet) and 1.75-2.50 (5H-multiplet), was identical with a dehydrogenation product obtained by heating of IIa with 10% palladium-carbon at 300° for 5 min.

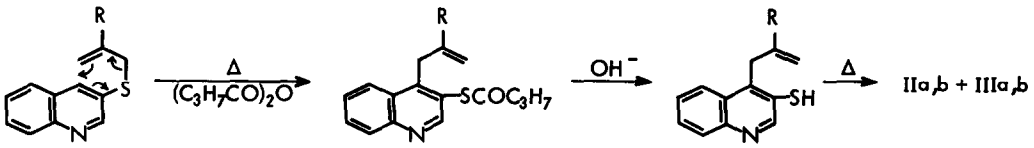
Similarly, rearrangement of Ib in dimethylaniline gave 15% of 2,2-dimethyl-1,2-dihydrothieno[2,3-c]quinoline (IIb), b.$p_{0.25}$ 140°; picrate, m.p. 206-206.5°, and 70.4% of 2-methyl-2,3-dihydro-1H-thiopyrano[2,3-c]quinoline (IIIb), m.p. 51-51.5°. The same products (IIb; 24% and IIIb; 61.5%) were also obtained from neat rearrangement of Ib. The NMR spectrum of IIb exhibited gem dimethyl (τ 8.39, 6H-singlet), methylene (τ 6.62, 2H-singlet), and C-4 aromatic (τ 1.31, 1H-singlet) proton signals and that of IIIb showed methyl (τ 8.76, 3H-doublet, J = 6.1 Hz), methine and two methylene (τ 6.75-7.90, 5H-multiplet), and C-5 aromatic (τ 1.42, 1H-singlet) proton signals. Desulfurization of IIb and IIIb with Raney nickel W-2 gave an identical alkylquinoline, b.$p_{0.25}$ 103°; picrate, m.p. 166-167°, which was identical with 4-isobutylquinoline (Vb) prepared by the reaction of sodium salt of lepidine with isopropyl bromide.



The thermal rearrangement of allyl 3-quinolyl sulfides (I) was thus shown to afford two isomeric cyclization products, 1,2-dihydrothieno[2,3-c]quinolines (II) and 2,3-dihydro-1H-thiopyrano[2,3-c]quinolines (III) in total yields over 80%. The initial formation of Claisen-type product, 4-allyl-3-mercaptoquinolines (VI), followed by their cyclization to II and III, is suggested as a pathway of this rearrangement on the basis of

the Claisen rearrangement of allyl 3-quinolyl ethers to 4-allyl-3-hydroxyquinolines accompanying their isomerization and cyclization products (5) and the thio-Claisen rearrangement of allyl 4-quinolyl sulfides to 2,3-dihydrothieno[3,2-c]quinolines via 3-allyl-4(1H)-quinolinethiones (1,2).

To trap the suggested intermediate, 3-mercapto-4-methallylquinoline (VIb), the rearrangement of Ib was carried out in the presence of 1.5 moles of butyric anhydride. VIb was thus trapped as its butyric ester (VIIb), oil; $\nu_{max}^{CHCl_3}$ 1708 (C=O), 1654, 895 cm^{-1} (>C=CH_2); picrate, m.p. 128-129°; in almost quantitative yield (a single product in GLC). The NMR spectrum of VIIb exhibited the presence of a methallyl side chain; τ 8.18 (3H-singlet, Me), 6.10 (2H-singlet, -CH_2-), and 5.71 and 5.20 (2H, =CH_2), besides a propyl group at τ 8.97, 8.35, and 7.3 and five aromatic protons at τ 1.75-2.65. Hydrolysis of VIIb with alkali under argon stream afforded VIb, m.p. 58-60°; $\nu_{max}^{CHCl_3}$ 1651, 896 cm^{-1} (>C=CH_2); τ 8.13 (Me), 6.18 (-CH_2-), 5.97 (S-H), 5.68, 5.20 (=CH_2), 1.22 (C_2-H). VIb was very unstable, especially under heating or exposure to sunlight or in air. On heating, VIb cyclized to IIb and IIIb in the identical product ratio with that in the rearrangement reaction of Ib.



Ia,b VIIb VIa,b

These results demonstrate that 4-allyl-3-mercaptoquinolines (VI) are sole intermediate in the thio-Claisen rearrangement of allyl 3-quinolyl sulfides (I) to 1,2-dihydrothieno[2,3-c]quinolines (II) and 2,3-dihydro-1H-thiopyrano[2,3-c]quinolines (III). The formation of VI from I is corresponding to [3,3] sigmatropic rearrangement of aromatic allyl sulfides (1-3). Details and mechanism of the cyclization reaction of VI to II and III will be reported in accompanying communication.

The NMR spectra were observed in deuteriochloroform containing tetramethylsilane as an internal standard by using a Varian A-60 spectrometer. Satisfactory analyses were obtained for all the new compounds reported.

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