Reactions of an *N*-Hydroxyquinazoline Structurally Analogous to Oncogenic *N*-Hydroxypurines[1]

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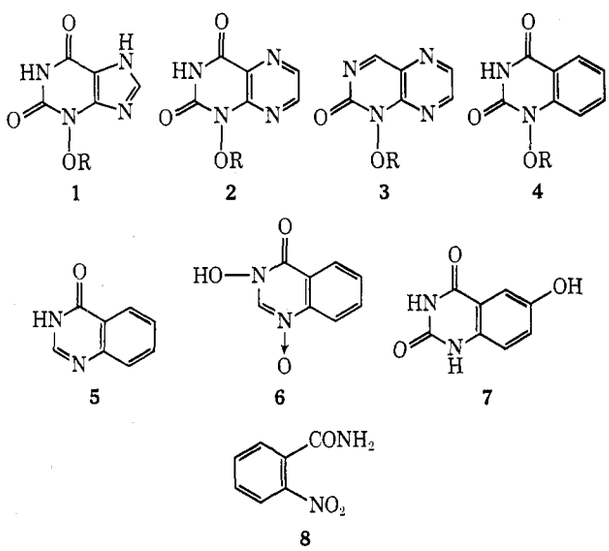
1,2,3,4-Tetrahydro-1-hydroxy-2,4-dioxoquinazoline, an analog of 3-hydroxyxanthine, was found to be less reactive than 3-hydroxyxanthine but more reactive than its pteridine analog. Thus, treatment of 1,2,3,4-tetrahydro-1-hydroxy-2,4-dioxoquinazoline with acetic anhydride gave a stable 1-acetoxy derivative. Upon treatment with phosphorus oxychloride it gave 6-chloro-1,2,3,4-tetrahydro-2,4-dioxoquinazoline, and with tosyl chloride, mesyl chloride, or *p*-nitrobenzenesulfonyl chloride it gave the corresponding 1,2,3,4-tetrahydro-2,4-dioxo-8-sulfonyloxyquinazolines. The formation of the 8-sulfonyloxyquinazolines probably proceeds *via* an intramolecular mechanism and the expected intermediate, 1,2,3,4-tetrahydro-2,4-dioxo-1-sulfonyloxyquinazoline, could be isolated. With peracetic acid 3,4-dihydro-4-oxoquinazoline gave 1,2,3,4-tetrahydro-1-hydroxy-2,4-dioxoquinazoline, rather than 1,2,3,4-tetrahydro-6-hydroxy-2,4-dioxoquinazoline, as was reported by others.

Chemical[3-7] and biochemical[8,9] studies have shown that the oncogenicity[10,11] of 3-hydroxyxanthine and some of its derivatives is paralleled by unique chemical reactivities of esters of these *N*-hydroxypurines. In a reaction termed the 3-acyloxypurine 8-substitution reaction, 3-acetoxyxanthine (**1**, R = Ac) undergoes, under mild conditions, an SN1′ reaction with nucleophiles to yield 8-substituted xanthines.[3-6]

In an investigation of analogs of 3-hydroxyxanthine to determine the features required for this type of reactivity the initial study[12] was of the *N*-hydroxypteridines (**2** and **3**, R = Ac, Ms, or Ts), which failed to undergo any similar substitution reactions. Their lack of reactivity could be attributed to the π-deficient character of the pyrazine ring in pteridines, as opposed to the π-excessive character of the imidazole ring of purines.[13]

We now report the reactions of 1,2,3,4-tetrahydro-1-hydroxy-2,4-dioxoquinazoline (**4**, R = H). It is more analogous to 3-hydroxyxanthine (**1**, R = H) since the π-electron density of the benzene ring lies between those of the imidazole ring of **1** and the pyrazine ring of **2**. Therefore the tendency of **4** to undergo a substitution reaction is expected to be between those of **1** and **2**.

Chiang and Li claimed[14,15] that oxidation of 3,4-dihydro-4-oxoquinazoline (**5**) with peracetic acid gave 3,4-dihydro-3-hydroxy-4-oxoquinazoline 1-oxide (**6**) together with some 1,2,3,4-tetrahydro-6-hydroxy-2,4-dioxoquinazoline (**7**), *o*-nitrobenzamide (**8**), *N*-formyl-*o*-nitrobenzamide, and benzoic acid.[14] They also claimed that **7** was obtained from **6** by boiling with acetic acid, which would be comparable to the reaction we are studying. Reinvestigation of their work showed that the compound to which they assigned the structure **7** was actually **4** (R = H). Its nmr spectrum showed a 4-proton ABCD pattern in the aromatic region, and it was found to be identical with that of an authentic sample.



1 **2** **3** **4**

5 **6** **7**

8

Authentic **4** (R = H) was prepared from 4-ethoxyquinazoline by an improvement of the published procedure.[16] When refluxed in acetic anhydride only the *N*-hydroxy function of **4** (R = H) was esterified, to yield **4** (R = Ac), and no products comparable to those from 3-hydroxyxanthine[3-6] resulted.

The 1-acetoxyquinazoline (**4**, R = Ac), unlike 3-acetoxyxanthine (**1**, R = Ac),[5] did not yield any substitution products when treated with a variety of nucleophiles, even under vigorous conditions. In boiling ethanol, only ethanolysis of **4** (R = Ac) to **4** (R = H) occurred, whereas the same treatment of **1** (R = Ac) gives 8-ethoxyxanthine in almost quantitative yield.[5]

When compound **4** (R = H) was refluxed with phosphorus oxychloride and phosphorus pentachloride, a substitution with elimination of the *N*-hydroxy group

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(2) G. Salemnick is a David A. Gimbel Fellow.

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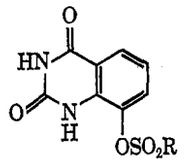
(16) H. Yamanaka, *Chem. Pharm. Bull.*, **7**, 152 (1959).

TABLE I

NMR CHEMICAL SHIFTS (δ, PPM)[a] AND COUPLING CONSTANTS (Hz)

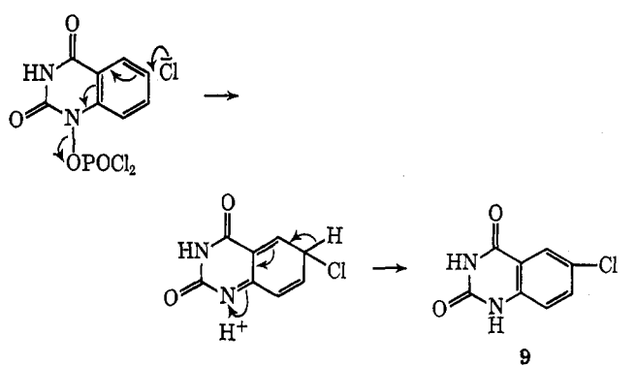


10

Compd	H^6 (t)	H^5 (dd)	H^7 (dd)	N^1 (s), N^3 (s)
10 (R = tolyl)[b]	7.17; $J_{6,5}$ = $J_{6,7}$ = 8	7.50; $J_{5,6}$ = 8, $J_{5,7}$ = 1.5	7.94; $J_{7,6}$ = 8, $J_{7,5}$ = 1.5	10.88;[c] 11.38[c]
10 (R = Me)[d]	7.23; $J_{6,5}$ = $J_{6,7}$ = 8	7.71; $J_{5,6}$ = 8, $J_{5,7}$ = 1.5	7.94; $J_{7,6}$ = 8, $J_{7,5}$ = 1.5	11.09;[c] 11.47[c]
10 (R = nitrophenyl)[e]	7.20; $J_{6,5}$ = $J_{6,7}$ = 8	7.56; $J_{5,6}$ = 8, $J_{5,7}$ = 1.5	7.90; $J_{7,6}$ = 8, $J_{7,5}$ = 1.5	10.98;[c] 11.38[c]

[a] Solvent DMSO-d_6. [b] Methyl singlet at 2.40, doublet at 7.44, $H^{3'} + H^{5'}$, J = 8, doublet at 7.84, $H^{2'} + H^{6'}$, J = 8.0. [c] Exchangeable with D_2O. [d] Methyl singlet at 3.61. [e] Doublet at 8.22, $H^{2'} + H^{6'}$, J = 8.0; doublet at 8.47, $H^{3'} + H^{5'}$, J = 8.0.

did occur, and 6-chloro-1,2,3,4-tetrahydro-1,4-dioxoquinazoline[17] was obtained. Presumably the dichlorophosphate ester was first formed, and this more effective leaving group facilitated the cleavage of the N–O bond. Nucleophilic substitution by chloride ion, an intermolecular process, gave **9**. Similar mechanisms

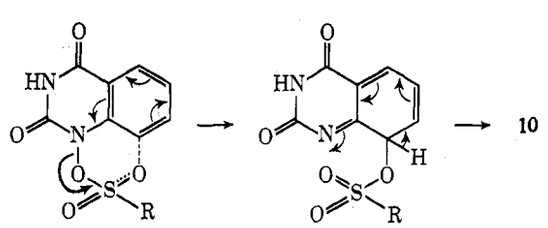


9

are involved in the reactions of pyridine *N*-oxide with phosphorus pentachloride[18,19] and 1,X-naphthyridine 1-oxides[20] with phosphorus oxychloride.

When 1,2,3,4-tetrahydro-1-hydroxy-2,4-dioxoquinazoline (**4**, R = H) was treated with tosyl chloride, mesyl chloride, or *p*-nitrobenzenesulfonyl chloride in pyridine at room temperature, the products were probably the result of an intramolecular rearrangement. The respective 8-sulfonyloxyquinazolines (**10**, R = Me, *p*-tolyl, *p*-$NO_2C_6H_4$) were obtained. The position of substitution was indicated by nmr spectra (Table I) which were quite definitive and which showed that compounds **10** (R = Me, *p*-tolyl, *p*-$NO_2C_6H_4$) each bore a substituent at the 8 position (see Table I). In addition, the position of the substitution was confirmed by treatment of compounds **10** (R = Me) or **10** (R = *p*-tolyl) with 0.1 *N* sodium hydroxide to give 1,2,3,4-tetrahydro-8-hydroxy-2,4-dioxoquinazoline, which was prepared unambiguously from 3-hydroxyanthranilic acid. Boiling **4** (R = H) with tosyl chloride in ethanol gave 1-ethoxy-1,2,3,4-tetrahydro-2,4-dioxoquinoline (**4**, R = Et) rather than a sulfonyloxy derivative. Similar treatment with even a large excess of tosyl chloride in methanol did not yield the 1-methoxy compound. The structure of the ethoxy compound was established by its nmr spectrum which gave an ABCD pattern in the aromatic region, and one OEt and one NH signal.

An attempted Reissert reaction of **4** (R = H) with benzoyl chloride in the presence of potassium cyanide in DMF at temperatures up to 100° gave unchanged starting material. With tosyl chloride, to obtain a better leaving group, and potassium cyanide (2 equiv) both 1,2,3,4-tetrahydro-2,4-dioxo-1-tosyloxyquinazoline (**4** = SO_2-*p*-tolyl) and the 8-tosyloxy isomer were obtained. With less potassium cyanide the formation of the 1-tosyloxyquinazoline was reduced. When sodium cyanide was used instead of potassium cyanide, the only product was the 8-tosyloxyquinazoline. The structure of the 1-tosyl isomer was confirmed from its nmr spectrum which showed a methyl signal at δ 2.40, aromatic protons, a multiplet at δ 7–8 integrating for eight protons, and a single exchangeable NH at δ 11.33. Since the reaction of **4** (R = H) with tosyl chloride gave only **10**, even under the influence of stronger competitive nucleophiles such as pyridine or cyanide ion, the formation of the 8-sulfonyloxyquinazoline is most likely the result of an intramolecular reaction within a solvent cage, as



A molecular model of the 1-tosyloxyquinazoline shows the oxygen of the $-SO_2$ group to be close to the 8 position of the quinazoline, and thus able to form a six-membered cyclic transition state. Cleavage of the N–O bond, hydrogen migration, and rearomatization would then yield the 8-sulfonyloxyquinazoline. An intramolecular mechanism is supported by the finding of only the 8-sulfonyloxyquinazolines, and no 6-substitution products. This rearrangement is comparable to that of 1-hydroxycarbostyril to 8-tosyloxy-

(17) F. Curd, J. Landquist, and F. Rose, *J. Chem. Soc.*, 1759 (1948).
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2-quinolone,[21] which has been proved by radioisotope labeling to be partially intramolecular. This rearrangement contrasts with the intermolecular SN1′ reaction in $POCl_3$–PCl_5, which yields **9**.

Esters of the 1-hydroxyquinazoline analog are thus intermediate in reactivity between the 1-hydroxypteridine analog[12] and 3-acetoxyxanthine.[5,6] They do undergo reactions involving substitution with rearrangement, but only with leaving groups better than acetate. This is in agreement with predictions made from the relative π characters of the benzene, pyrazine, and imidazole rings in the fused ring systems. Should an ester of 1,2,3,4-tetrahydro-1-hydroxy-2,4-dioxoquinazoline be formed *in vivo*,[9] it would not be expected to be reactive under physiological conditions, and it is improbable that **4** (R = H) would be an oncogen.[11]

Experimental Section

The uv spectra were determined with a Cary 15 spectrometer. Analyses were performed by Galbraith Laboratories, Inc., Knoxville, Tenn. Nmr spectra were determined with a Varian A-60 spectrometer, in Me_2SO-d_6 with tetramethylsilane as an internal reference. The melting points are uncorrected. Paper chromatography, ascending, on Whatman No. 1 paper was used to check the purity of each of the compounds prepared. For Dowex 50 chromatography BioRad AG-50, 8X, 200–400 mesh [H^+] resin was used.

4-Ethoxy-1,2-dihydro-1-hydroxy-2-oxoquinazoline (12) and 1,2,3,4-Tetrahydro-1-hydroxy-2,4-dioxoquinazoline (4, R = H).—**12** was prepared from 4-ethoxyquinazoline[16] by oxidation with 2 equiv, instead of 1 equiv, of ethereal perphthalic acid. Upon isolation as described an improved yield of **12** (51%, lit.[16] 26%) and some 4-ethoxyquinazoline 1-oxide (17%) was obtained. Hydrolysis of **12** in 50% acetic acid gave a quantitative yield of **4** (R = H): uv max in methanol, nm ($\epsilon \times 10^{-3}$), 246 (8.48), 316 (3.64); nmr δ 7.62 (m, 4 H, $H^5 + H^6 + H^7 + H^8$), 11.10 (s, 1 H, H^1), 11.60 (s, 1 H, H^3).

1-Acetoxy-1,2,3,4-tetrahydro-2,4-dioxoquinazoline (4, R = Ac).[22]—**4** (R = H) (0.60 g, 0.0033 mol) was refluxed with acetic anhydride (10 ml) for 4 hr and cooled. The **4** (R = Ac) was collected and recrystallized from ethanol, 0.40 g (55%), colorless needles: mp 225°; uv max in ethanol, nm ($\epsilon \times 10^{-3}$), 243 (8.42), 308 (3.96).

Anal. Calcd for $C_{10}H_8N_2O_4$: C, 54.52; H, 3.66; N, 12.72. Found: C, 54.26; H, 3.63; N, 12.45.

6-Chloro-1,2,3,4-tetrahydro-2,4-dioxoquinaoline (9).—A stirred solution of **4** (R = H) (0.45 g, 0.0025 mol) and phosphorus pentachloride (1.6 g) in phosphorus oxychloride (5 ml) was refluxed for 1.5 hr. The cooled mixture was poured into ice-water (100 ml) and the clear supernatant was decanted. The solid residue was extracted with ether (100 ml); the ether was washed with water, dried over sodium sulfate, and evaporated to dryness. Concentrated HCl (20 ml) was added, the solution heated under reflux for 3 hr, and **9** crystallized on cooling. Recrystallization from 50% acetic acid gave **9**, 0.10 g (20%), colorless needles: mp 344° (lit.[17] mp 345–348°); nmr δ 7.20 (d, 1 H, H^8, $J_{8,7} = 8.5$ Hz), 7.71 (dd, 1 H, H^7, $J_{7,8} = 8.5$ Hz, $J_{7,5} = 2$Hz), 7.84 (d, 1 H, H^5, $J_{5,7} = 2$ Hz), 11.25, 11.41 (2, 1 H each, N_1H, N_3H, exchangeable with D_2O); uv max in ethanol, nm ($\epsilon \times 10^{-3}$), 245 (11.5), 252 (11.3), 322 (3.42).

Anal. Calcd for $C_8H_5ClN_2O_2$: C, 48.87; H, 2.56; N, 14.25; Cl, 18.03. Found: C, 48.62; H, 2.61; N, 13.99; Cl, 18.19.

1,2,3,4-Tetrahydro-2,4-dioxo-8-tosyloxyquinazoline (10, R = p-Tolyl). A.—To a stirred solution of **4** (R = H) (0.178 g, 0.001 mol) in dry pyridine (4 ml), tosyl chloride (0.210 g, 0.0011 mol) was added in small portions at room temperature. After stirring for 48 hr most of the pyridine was evaporated under vacuum (<40°), water was added, and the white precipitate was collected. Two recrystallizations from ethanol gave the **10** (R = *p*-tolyl), 0.13 g (39%), colorless crystals, mp 220°.

B.—Tosyl chloride (420 mg, 0.0022 mol) was added to a solution of the **4** (R = H) (356 mg, 0.002 mol) and sodium cyanide (212 mg, 0.004 mol) in dry DMF (45 ml). The reaction mixture was stirred at room temperature for 61 hr. The DMF was evaporated under vacuum (<40°), and a small amount of water was added to the oily residue to precipitate the tosyloxyquinazoline. Recrystallization of the crude product from methanol gave the pure 8-tosyloxyquinazoline, 158 mg (24%): uv max in ethanol, nm ($\epsilon \times 10^{-3}$), 307 (4.12).

Anal. Calcd for $C_{15}H_{12}N_2O_5S$: C, 54.21; H, 3.64; N, 8.43; S, 9.65. Found: C, 54.38; H, 3.61; N, 8.37; S, 9.83.

1,2,3,4-Tetrahydro-8-mesyloxy-2,4-dioxoquinazoline (10, R = Me).—Methanesulfonyl chloride (0.1 ml) was added to a cooled stirred solution of **4** (R = H) (0.178 g, 0.001 mol) in pyridine (4 ml). It was stirred for 72 hr at room temperature; the pyridine was evaporated under vacuum, water added, and the white precipitate collected. Two recrystallizations from 50% acetic acid gave the **10** (R = Me), 0.077 g (30%): mp 345° dec; uv max in ethanol, nm ($\epsilon \times 10^{-3}$), 312 (saturated solution).

Anal. Calcd for $C_9H_8N_2O_5S$: C, 42.18; H, 3.15; N, 10.93; S, 12.51. Found: C, 42.37; H, 3.26; N, 11.00; S, 12.31.

8-p-Nitrobenzenesulfonyloxy-1,2,3,4-tetrahydro-2,4-dioxoquinazoline (10, R = p-$NO_2C_6H_4$).—This was prepared in a manner similar to that for tosyloxyquinazoline and yielded light yellow crystals (44%): mp 282–283°; uv max in methanol, nm ($\epsilon \times 10^{-3}$), 243 (17.1), 310 (4.20).

Anal. Calcd for $C_{14}H_9N_3O_7S$: C, 46.28; H, 2.49; N, 11.56; S, 8.82. Found: C, 46.14; H, 2.36; N, 11.42; S, 8.91.

1,2,3,4-Tetrahydro-2,4-dioxo-1-tosyloxyquinazoline (4, R = SO_2-p-tolyl).—*p*-Toluenesulfonyl chloride (210 mg, 0.0011 mol) was added to a solution of **4** (R = H) (178 mg, 0.001 mol) and potassium cyanide (130 mg, 0.002 mol) in DMF (30 ml). After stirring at room temperature for 4 days, the DMF was evaporated nearly to dryness under vacuum (<40°). The addition of water to the oily residue precipitated **4** (R = SO_2-*p*-tolyl) (205 mg), and two recrystallizations from methanol gave 57 mg (19%) of colorless crystals: mp 260–261°; uv max in ethanol, nm ($\epsilon \times 10^{-3}$), 314 (3.65).

When 1 equiv of potassium cyanide was used, no 1-tosyloxy derivative could be isolated in pure form.

Anal. Calcd for $C_{15}H_{12}N_2O_5S$: C, 54.21; H, 3.64; N, 8.43; S. 9.65. Found: C, 54.09; H, 3.70; N, 8.53; S, 9.69.

1,2,3,4-Tetrahydro-8-hydroxy-2,4-dioxoquinazoline (11). A.—Potassium cyanate (0.360 g, 0.0045 mol) in water (5 ml) was added in portions to a suspension of 3-hydroxyanthranilic acid (0.530 g, 0.0034 mol) in water (15 ml) containing acetic acid (0.26 ml). After being stirred 25 min at 35° sodium hydroxide (4.78 g, 0.12 mol) was added in small portions, with cooling (<30°). After 2 days the solution was brought to pH 5 with 50% H_2SO_4 and the precipitate collected. It was absorbed on a Dowex 50 [H^+] column (4.5 × 26 cm) which was eluted with water. Evaporation of the solution gave **11**, 150 mg (23%), which was recrystallized from water as white needles: mp >300° (sublimation); ferric chloride test green in ethanol; paper chromatography CH_3CN:H_2O (3:1) R_f 0.80, CH_3CN:H_2O:NH_4OH (7:2:1) R_f 0.57, NH_4Cl (3%) R_f 0.39; uv max in methanol, nm ($\epsilon \times 10^{-3}$), 322 (3.57).

Anal. Calcd for $C_8H_6N_2O_3 \cdot {}^1/_2H_2O$: C, 51.34; H, 3.77; N, 14.96. Found: C, 51.56; H, 3.50; N, 14.90.

B.—The 8-tosyloxyquinazoline (0.166 g) was added to 0.5 *N* NaOH (20 ml) and heated on the steam bath for 6 hr. The mixture was absorbed on a Dowex 50 [H^+] column (4.5 × 26 cm), from which elution with water gave *p*-toluenesulfonic acid and then the product. The concentrated eluate (40 mg, 43%) of the product was recrystallized from water as white needles: mp >300° (sublimation); ferric chloride test green in ethanol; paper chromatography CH_3CN:H_2O (3:1) R_f 0.80, CH_3CN:H_2O:NH_4OH (7:3:1) R_f 0.57, NH_4Cl (3%) R_f 0.39.

Anal. Calcd for $C_8H_6N_2O_3 \cdot {}^1/_2H_2O$: C, 51.34; H, 3.77; N, 14.96. Found: C, 51.42; H, 3.64; N, 14.68.

1-Ethoxy-1,2,3,4-tetrahydro-2,4-dioxoquinazoline (4, R = Et).—**4** (R = H) (500 mg) in ethanol (50 ml) was refluxed with tosyl chloride (500 mg) for 3 hr and the solution evaporated to dryness. The residue in dilute sodium hydroxide (0.1 *N*, 20 ml) was absorbed on a Dowex 50 [H^+] column. Elution with water gave the unchanged starting material (330 mg) as the first fraction, followed by **4** (R = Et), 190 mg: mp 170° (from water); uv max in methanol, nm ($\epsilon \times 10^{-3}$), 244 (8.87), 312 (3.99).

(21) K. Ogino and S. Oae, *Tetrahedron*, **27**, 6037 (1971).

(22) This compound was incorrectly identified as 6-acetoxy-1,2,3,4-tetrahydro-2,4-dioxoquinazoline.[14]

Anal. Calcd for $C_{10}H_{10}N_2O_3$: C, 58.25; H, 4.89; N, 13.59. Found: C, 58.05; H, 4.84; N, 13.39.

Acknowledgment.—We thank Mr. Marvin J. Olsen and Mr. Gerald Reiser for the nmr and uv spectra.

Registry No.—**4** (R = H), 13300-21-5; **4** (R = Ac), 40919-19-5; **4** (R = SO_2-*p*-tolyl), 40919-20-8; **4** (R = Et), 40919-21-9; **9**, 1640-60-4; **10** (R = *p*-tolyl), 40919-23-1; **10** (R = Me), 40919-24-2; **10** (R = *p*-nitrophenyl), 40919-25-3; **11**, 40919-26-4; **12**, 40919-27-5; phosphorus pentachloride, 10026-13-8; tosyl chloride, 98-59-9; 3-hydroxyanthranilic acid, 548-93-6.

Quinoxaline 1,4-Dioxides. Nucleophilic Displacement of Sulfinyl and Sulfonyl Groups in Acid Media. A Novel Method for the Preparation of 2-Haloquinoxaline 1,4-Dioxides

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The oxidation of the quinoxaline 1,4-dioxides **2a** and **2b** with *1* or *2* equiv of *m*-chloroperbenzoic acid furnished the corresponding sulfoxides (**3a** and **3b**) and sulfones (**4a** and **4b**), respectively, in high yields. Treatment of these compounds with aqueous halogen acids furnished the corresponding 2-haloquinoxaline 1,4-dioxides (**5**), almost in quantitative yields. The action of organic acids on these sulfoxides and sulfones produced, instead of the expected 2-acyloxy derivatives, esters of 1-hydroxyquinoxalin-2-one 4-oxide (**6**). The mechanism and the potential synthetic utility are discussed.

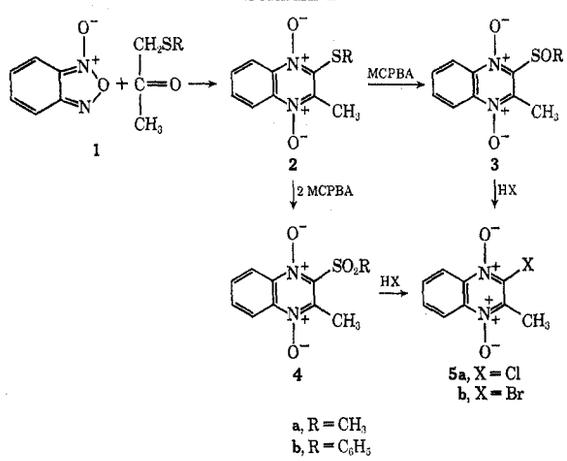
There are three general methods for the preparation of quinoxaline 1,4-dioxides: peracid oxidation of the parent amine,[2] the condensation of enamines and enolates with benzofurazan 1-oxide (BFO, **1**),[3] and the condensation of α diketones with *o*-benzoquinone dioxime.[4] However, none of these methods can be used for the synthesis of 2-haloquinoxaline 1,4-dioxides, owing to difficulties encountered in the oxidation of 2-halo aromatic amines, and the failure of 2-halo ketones to react successfully with BFO. The present work describes a novel nucleophilic displacement of sulfinyl and sulfonyl groups which provides a simple method for the synthesis of 2-haloquinoxaline 1,4-dioxides in high yield.

Preparation of the starting materials was accomplished according to earlier procedures.[3] Thus, condensation of BFO with acetonylmethyl sulfide and acetonylphenyl sulfide[5] furnished the corresponding quinoxaline 1,4-dioxides **2a** and **2b**, respectively (50–60%). These were in turn oxidized with either *1* or *2* equiv of *m*-chloroperbenzoic acid (MCPBA) to yield the corresponding sulfoxides (**3a** and **3b**) and sulfones (**4a** and **4b**), respectively, in 80–90% yields.

Treatment of **3** or **4** with aqueous hydrochloric or hydrobromic acid under mild conditions gave the quinoxaline 1,4-dioxides **5a** and **5b**, respectively, almost in quantitative yields. Scheme I summarizes the above reactions.

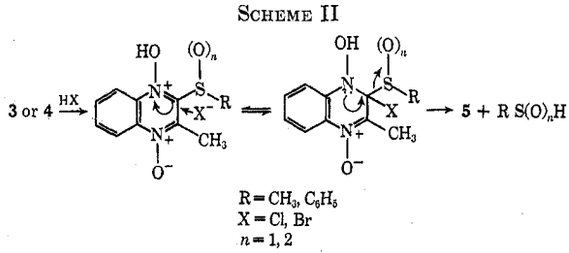
The structures of **5a** and **5b** were based on mass spectral data, which showed the expected molecular ion doublets indicating the presence of chlorine and bromine. The nmr spectra of **5a** and **5b** were consistent with the proposed structures and each consisted of a three-hydrogen methyl singlet at δ 2.76 (**5a**) and 2.88 (**5b**). The typical aromatic A_2B_2 pattern observed for other quinoxaline 1,4-dioxides was preserved in **5a** and **5b** and appeared at δ 7.78 and 8.6.

SCHEME I



A plausible mechanism for these reactions is depicted in Scheme II.

SCHEME II



Initial protonation of the *N*-oxide group is probably involved followed by halide attack at C-2, with subsequent elimination of a sulfinic or sulfenic acid. Support for this mechanism came from the reaction of hydrochloric acid with the phenyl sulfoxide **3b**. In addition to the chloro compound **5a**, there were isolated two additional compounds, namely diphenyl disulfide[6] and *S*-phenyl benzenethiosulfonate[7] in 84

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