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Acid-catalyzed Cyclization of Chalcones derived from Various Nitrogenous Heteroaromatic Compounds. II[1]

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1-Cinnamoylisoquinoline (I) was treated with perchloric acid in ethanol to give 2,5-dihydro-1-oxo-3-phenyl-[1*H*]pyrrolo[2,1-*a*]isoquinolinium perchlorate (V) in the yield of 48.1%. V was derived to 1-(4-nitrobenzoyloxy)-3-phenyl-[1*H*]pyrrolo[2,1-*a*]isoquinoline (VI) by means of the Shotten–Baumann reaction.

3-Methylquinoxalin-2-yl 4-phenyl-1,3-butadienyl ketone (VIIa) was treated with acid to give 3-hydroxy-4-methyl-1-styrylpyrrolo[1,2-*a*]quinoxalinium perchlorate (VIIIa) in quantitative yield. VIIIa was treated with diazomethane to give 3-methoxy-4,5-dimethyl-1-styrylpyrrolo[1,2-*a*]quinoxalinium perchlorate (XI). VIIIa gave a monobromide (XIIa) on treatment with bromine in carbon tetrachloride. The rate of acid-catalyzed cyclization of 3-methylquinoxalin-2-yl 4-(4-nitrophenyl)-1,3-butadienyl ketone (VIIb) was slower than that of VIIa.

Attempts to cyclize XIV intramolecularly to 2,5-dihydro-1-phenylpyrrolizin-3[1*H*]-one (XVI) were unsuccessful under various conditions.

Keywords——chalcone; acid-catalyzed cyclization; Michael addition; pyrrolo[1,2-*a*]quinoxaline; pyrrolo[2,1-*a*]isoquinoline

In our previous paper,[1] we described an interesting isomerization or cyclization reaction of chalcones derived from 2-acetylquinoxalines, 2-acetylpyridine, 2-acetylquinoline, and 2-acetylpyrazine. Furthermore, the reactions of these products with diazomethane, acetic anhydride, and dimethyl acetylenedicarboxylate were mentioned. In this paper, the scope and limitations of this cyclization reaction will be discussed.

First, the reaction of 1-cinnamoylisoquinoline (I), the chalcone derived from 1-acetylisoquinoline, was examined. I was treated with acetic anhydride in the presence of a catalytic amount of trifluoroacetic acid (TFA). The conditions were those adopted for the cyclization reaction of 2-(2-furfurylidene)acetylquinoline (II).[1] However, I gave a dimerized product, 1-hydroxy-3-phenyl-2-(1-phenylpyrrolo[2,1-*a*]isoquinolin-3-yl)-pyrrolo[2,1-*a*]isoquinoline (III), and the starting material in yields of 7.4 and 55.3%, respectively. The infrared (IR) spectrum of III exhibited no carbonyl band and the formula was supported by the mass spectrum and the results of elemental analysis. On the other hand, I was treated with perchloric acid in ethanol to give a crystalline product. The conditions were those used in the cyclization reaction of 2-(4-methoxycinnamoyl)pyridine (IV).[1] The product showed a ABX type signal in the nuclear magnetic resonance (NMR) spectrum at δ 3.66, 4.10, and 6.56 ppm, and a carbonyl band at abnormally high frequency (1760 cm^{-1}) in the IR spectrum. The mass spectrum (MS) of the product showed the parent peak at m/e 259, corresponding to the molecular weight of I. Thus, the product from I under these conditions was proved to be 2,3-dihydro-1-oxo-3-phenyl-[1*H*]-pyrrolo[2,1-*a*]isoquinolinium perchlorate (V). The yield of V was 48.1%. The abnormally high frequency of the carbonyl band in the IR spectrum may be explained in terms of electron deficiency in the carbonyl group. V was derived to an enol benzoate, 1-(4-nitrobenzoyloxy)-3-phenyl-[1*H*]pyrrolo[2,1-*a*]isoquinoline (VI), by means of the Schotten–Baumann reaction. VI exhibited no aliphatic proton signal in the NMR spectrum and showed a carbonyl absorption at 1730 cm^{-1} in the IR spectrum. The formula of

VI was confirmed by the elemental analysis. Thus, it was confirmed that the cyclizatin product could be also obtained from I.

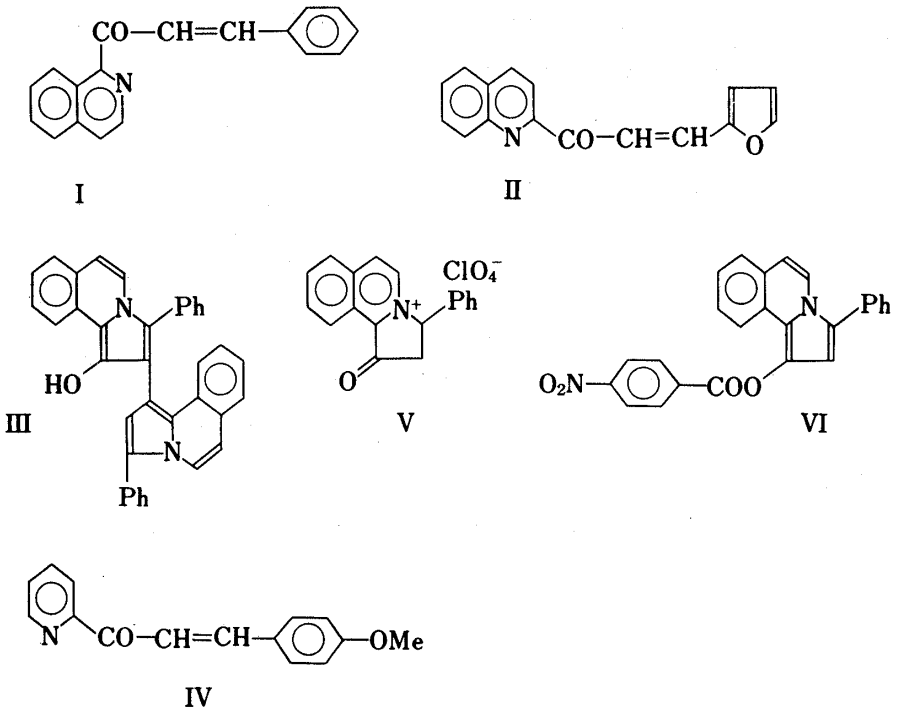

Chart 1

Next we examined the acid-catalyzed cyclization reaction for a vinylogous chalcone, 3-methylquinoxalin-2-yl 4-phenyl-1,3-butadienyl ketone (VIIa), which was prepared from 2-acetyl-3-methylquinoxaline and cinnamaldehyde by the use of a base catalyst in ethanol. In the IR spectrum VIIa exhibited a carbonyl band at 1670 cm,$^{-1}$ and in the NMR spectrum no fine splitting signals due to aromatic and vinylic proton were seen. Therefore it was not possible to determine the configuration of the butadiene unit. VIIa was treated with 60% perchloric acid in ethanol to give a perchlorate of the cyclized product, which exhibited absorption signals at 1610 and 1590 cm^{-1} in the IR spectrum and singlet signals at δ 2.84 and 6.72 ppm due to vinylic methyl protons and a vinylic proton, respectively. From these physical data, we concluded the structure of this product to be not 5-hydroxy-6-methyl-1-styrylazepino[1,2-*a*]quinoxalinium perchlorate (IX), but 3-hydroxy-4-methyl-1-styrylpyrrolo[1,2-*a*]quinoxalinium perchlorate (VIIIa). Because any vinylic proton in IX could not be observed as a singlet signal in the NMR spectrum. The yield of VIIIa from VIIa was 98.9%. The elemental analysis revealed that VIIIa has one molar equivalent of crystal water. This was supported by the measurement of the melting point; thus, it has a double melting point; mp 137—138°C and mp 209—210°C. VIIIa was derived to its enol *p*-nitrobenzoate (Xa) by the Schotten-Baumann method in a yield of 81.8%; Xa showed a carbonyl band at 1745 cm^{-1} in the IR spectrum and a singlet signal at δ 8.53 ppm due to the *p*-nitrobenzoyl moiety in the NMR spectrum.

VIIIa was treated with diazomethane-etherate to give a dimethylated quaternary salt, 3-methoxy-4,5-dimethyl-1-styrylpyrrolo-[1,2-*a*]quinoxalinium perchlorate (XI), which did not melt below 300°C and showed three singlet peaks at δ 3.13, 4.06, and 4.25 ppm due to vinylic, *N*-quaternary, and *O*-methyl moieties, respectively, and at δ 6.96 ppm due to the C_2-proton in the NMR spectrum. The composition was confirmed by the elemental analysis. Then, VIIIa was treated with bromine in carbon tetrachloride to give quantitatively the monobromide (XIIa), which was further treated with diazomethane to give a corresponding methyl ether (XIIb). XIIb melted at 136—138°C and showed no signal due to a C_2-proton in the NMR

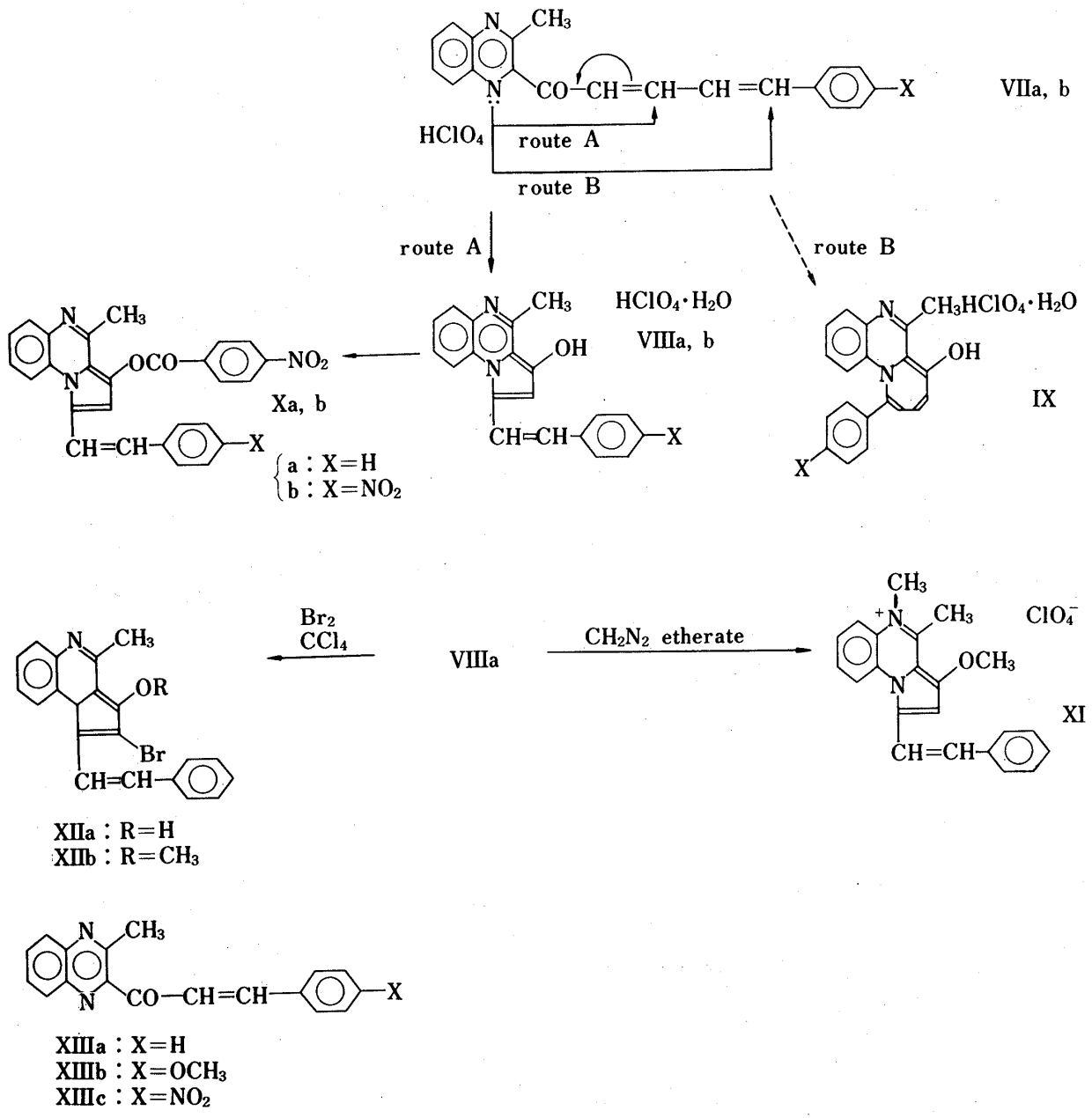

Chart 2

spectrum; the parent peaks at *m/e* 392 and 394 showed equal intensity in the mass spectrum. Thus, it became clear that VIIIa was not brominated at the styryl double bond and only the C_2-position was substituted by bromine.

In a similar fashion, acid-catalyzed cyclization of 3-methylquinoxalin-2-yl 4-(4-nitrophenyl)-1,3-butadienyl ketone (VIIb), epared from 2-acetyl-3-methylquinoxaline and *p*-nitrocinnamaldehyde in the yield of 44.5%, was examined. VIIb showed a singlet methyl signal at δ 3.50 ppm in the NMR spectrum. The cyclized product was isolated as a perchlorate (VIIIb), which also contains one molar equivalent of crystal water. VIIIb showed singlet signals at δ 3.10 and 6.99 ppm due to vinylic methyl and C_2-proton. The rate of cyclization in TFA was measured by means of NMR spectrography. The ratios of products to the starting materials were calculated from the signal integrals of the corresponding vinylic methyl protons. In the case of VIIa, the conversion to the cyclized product was completed within 30 min. On the other hand, it took about 18 h to convert VIIb to the corresponding product. It is interesting to

compare these data with those obtained for the 3-methyl-2-(4-substituted cinnamoylquinoxaline series (XIIIa, b, and c).[1] Although the data were not given in our report,[1] in TFA XIIIa and XIIIb changed spontaneously to the corresponding cyclized products. On the other hand, it took about 10 d to convert XIIIc to its cyclized product. These phenomena could be explained in terms of differences in the direction and amount of the electron current near the carbon to be cyclized between the VII and XIII series.

Next, we examined the possibility of intramolecular cyclization of 2-cinnamoyl[1*H*]pyrrole (XIV) to 2,3-dihydro-1-phenylpyrrolizin-3[1*H*]-one (XVI). XIV was prepared from 2-acetyl[1*H*]pyrrole and benzaldehyde by stirring overnight with sodium hydroxide in aqueous ethanol in a yield of 32.6%.[2] On stirring the mixture of the two starting materials for a short time, 2-hydroxy-2-phenylethyl 2[1*H*]-pyrrolyl ketone (XVa) was formed in a conversion yield of 39.9% with recovery of 2-acetylpyrrole. XVa exhibited an absorption maximum at 1630 cm^{-1} due to the carbonyl group in the IR spectrum. In the NMR spectrum of XVa, a doublet signal due to methylene protons and a triplet signal due to the proton at the carbon carrying the hydroxyl group were found at δ 3.16 and 5.26 ppm, respectively. XVa was treated with acetic anhydride in pyridine to give XIV and 2-acetoxy-2-phenylethyl 2[1*H*]-pyrrolyl ketone (XVb) in yields of 11.4 and 58.0%, respectively. XVb exhibited an ABX type signal at δ 3.10, 3.56, and 6.40 ppm with coupling constants of 16, 9, and 5.5 Hz in the NMR spectrum. The elimination of acetic acid from XVb was performed by distillation to give XIV in a yield of 63.4%.

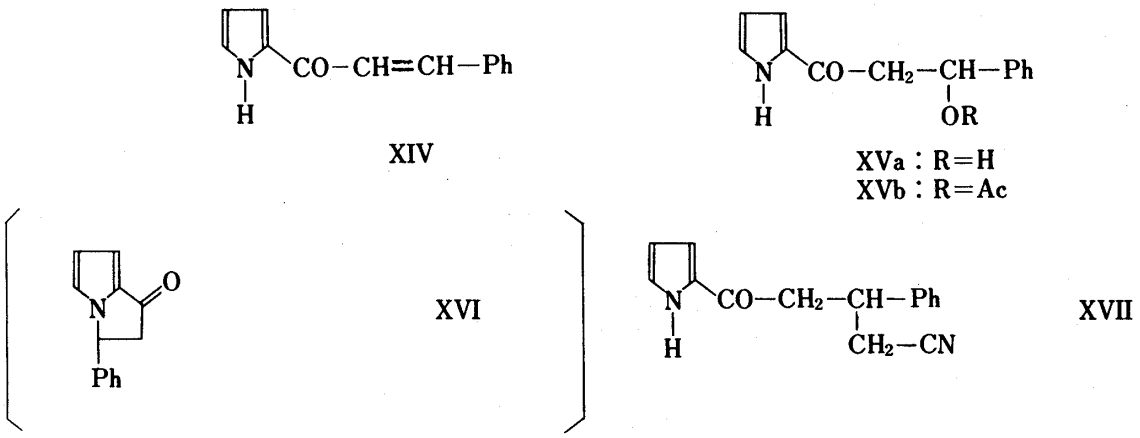

Chart 3

The possibility of intramolecular cyclization of XIV to XVI was checked by NMR spectroscopy but the signals scarcely changed on standing for 2 d in TFA. When XIV was treated with perchloric acid in ethanol, it gave only an unidentifiable mixture. An attempt at intramolecular cyclization in the presence of acid was unsuccessful, so a base-catalyzed intramolecular Michael addition reaction was tried in acetonitrile. However, the isolated product was only the Michael adduct of the solvent, 3-cyano-2-phenylpropyl 2[1*H*]-pyrrolyl ketone (XVII). The results of this Michael reaction have already been reported.[2]

Experimental

All melting points are uncorrected. IR spectra were determined by using a JASCO IRA-1 diffraction grating spectrophotometer; absorption data are given in cm^{-1}. NMR spectra were recorded on Varian EM-360, JEOL PMX-60, and Varian EM-390 spectrometers with tetramethylsilane (TMS) as an internal standard. The chemical shifts and coupling constans (J) are given in δ and Hz, respectively. Mass spectra were measured with a JEOL D-200 (70 eV, direct inlet system) spectrometer. Ultraviolet (UV) spectra were obtained in MeOH with a Hitachi 200-10 spectrophotometer, and absorption maxima are given in nm. All solvents were removed by evaporation under reduced pressure.

1-Cinnamoylisoquinoline (I)——A 10% aq. solution of NaOH (0.47ml, 1.17mmol) was added to an ethanolic mixture of 1-acetylisoquinoline (1.0 g, 5.9 mmol, prepared from 1-cyanoisoquinoline[3] and methyl magnesium iodide) and benzaldehyde (0.62 g, 5.9 mmol) with stirring at room temperature. The mixture was stirred for 1 h, then water was added to separate I, which was collected on a filter and recrystallized from aq. EtOH. The yield was 0.77 g (50.8%). mp 86—87°C. IR (Nujol): $\nu_{C=O}$ 1667, ν1605, 1580. NMR ($CDCl_3$): 7.26—8.01 (11H, m), 8.63 (1H, d, J=5.5), 8.8—9.1 (1H, m). *Anal.* Calcd for $C_{18}H_{13}NO$: C, 83.37; H, 5.05; N, 5.40. Found: C, 83.22; H, 5.01; N, 5.50.

1-Hydroxy-3-phenyl-2-(1-phenylpyrrolo[2,1-*a*]isoquinolin-3-yl)-pyrrolo[2,1-*a*]isoquinoline (III)——A mixture of I (0.47g), Ac_2O (10 ml) and TFA (a few drops) was stirred on a water bath for 10 min. The reaction mixture was poured into ice-cooled aq. pyridine to give a crystalline material, which was purified by silica gel column chromatography. IIIa (0.03 g) and I (0.26 g) were eluted successively with benzene. III was recrystallized from benzene. mp 256—258°C. IR (KBr): ν 1600, 1560. NMR ($CDCl_3$): 6.70 (3H, t.like), 7.1—7.8 (16H, m), 8.00 (2H, d, J=7), 8.70 (2H, m). MS m/e (%): 502 (M+2, 12), 501 (M−1, 60), 500 (M^+, base peak), 128 (isoquinoline, 82). *Anal.* Calcd for $C_{36}H_{24}N_2O$: C, 86.37; H, 4.83; N, 5.60. Found: C, 86.74; H, 4.88; N, 5.53.

2,3-Dihydro-1-oxo-3-phenyl-[1*H*]pyrrolo[2,1-*a*]isoquinolinium Perchlorate (V)——A mixture of I (0.39 g), 60% $HClO_4$ (1 ml), and EtOH (1 ml) was refluxed for 50 min. The crystalline solid obtained after concentration of this solution was washed with EtOH. mp 190—218°C. It was difficult to recrystallize. The crude yield was 0.26 g (48.1%). IR (KBr): $\nu_{C=O}$ 1760, ν1625, 1600. MS m/e (%): 260 (M+1, 31), 259 (M^+, base peak). 258 (M−1, 64), 128 (isoquinoline, 100). NMR (TFA): 3.66 (1H, dd, J=18, 5, C_2-H), 4.10 (1H, dd, J=18, 8, C_2-H), 6.56 (1H, dd, J=8, 5, C_1-H).

p-Nitrobenzoate of V (VI): A stirred solution of the above perchlorate (V, 0.26 g, 0.72 mmol), *p*-nitrobenzoyl chloride (0.22 g, 1.2 mmol) in CH_2Cl_2 (3.6 ml) was treated with 10% aq. NaOH solution (1.8 ml, 4.5 mmol).[4] The mixture was stirred for 1 h at room temperature, then the CH_2Cl_2 layer was separated and the aq. solution was extracted with CH_2Cl_2. The combined organic layer was washed with brine and dried. The crystalline solid was washed with a small amount of $CHCl_3$. It was difficult to recrystallize. mp 226—228°C. IR (KBr): $\nu_{C=O}$ 1730, $\nu_{C=C}$ 1600. NMR (TFA): 6.75 (1H, d, J=2), 7.3—7.7 (4H, m), 7.87 (1H, d, J=2), 8.0—8.5 (5H, s), 8.56 (4H, s), 9.13 (1H, dm, J=7). *Anal.* Calcd for $C_{25}H_{16}N_2O_4$: C,73.52; H,3.95; N,6.86. Found:C, 73.56; H,3.98; N,7.19.

3-Methylquinoxalin-2-yl 4-phenyl-1,3-butadienyl Ketone (VIIa)——A solution of 10% NaOH (0.34 ml, 0.8 mmol) was added dropwise to an alcoholic mixture of 2-acetylquinoxaline[5] (0.75 g, 4 mmol) and cinnamaldehyde (0.54 g, 4.1 mmol). The whole was stirred for 1 h at room temperature to give a yellow precipitate which was collected on a filter and recrystallized from benzene to give a yellow sand. mp 173—174°C. IR (Nujol): $\nu_{C=O}$ 1670, ν1580. NMR ($CDCl_3$): 3.00 (3H, s), 6.9—8.4 (13H, m). *Anal.* Calcd for $C_{20}H_{16}N_2O$: C, 79.98; H, 5.34; N, 9.33. Found: C, 80.18; H, 5.37; N, 9.34.

3-Hydroxy-4-methyl-1-styrylpyrrolo[1,2-*a*]quinoxalinium Perchlorate (VIIIa)——An ethanolic solution of VIIa (2.9 g) and 60% $HClO_4$ (10 ml) was refluxed for 9—10 h. A crystalline product was collected on a filter and recrystallized from EtOH yellow woolly product. mp 136—137°C (monohydrate), mp 209—210°C (anhydrous). The yield was 3.9 g (98.9%). IR (Nujol): ν 1610, 1590. NMR (TFA): 2.84 (3H, s, vinylic CH_3), 6.72 (1H, s, vinylic H), 7.0—8.2 (11H, m), 10.25 (1H, br s, -OH). *Anal.* Calcd for $C_{20}H_{17}ClN_2O_5 \cdot H_2O$: C, 57.36; H, 4.57; N, 6.69. Found: C, 57.74; H, 4.41; N, 6.78.

p-Nitrobenzoate of VIIIa (Xa): In a manner similar to that described for Vl, VIIIa (0.83 g, 2 mmol) was esterified with *p*-nitrobenzoyl chloride (0.6 g, 3.2 mmol). The crystalline product was recrystallized from DMSO. The yield was 0.74 g (81.8%). mp 234—235°C. IR (KBr): $\nu_{C=O}$ 1730. NMR (TFA): 3.22 (3H, s), 7.3—8.1 (11H, m), 8.53 (5H, s). *Anal.* Calcd for $C_{27}H_{19}N_3O_4$: C, 72.15; H, 4.26; N, 9.35. Found: C, 72.12; H, 4.27; N, 9.49.

4,5-Dimethyl-5-methoxy-1-styrylpyrrolo[1,2-*a*]quinoxalinium Perchlorate (XI)——Excess diazomethane etherate solution was added to a methanolic solution of VIIIa (0.3 g). A crystalline product was collected on a filter after 18 h and washed with Et_2O. It was difficult to recrystallize. mp >300°C. The yield was 0.23 g (74.3%). NMR (TFA): 3.13, 4.06, and 4.25 (each 3H, s), 7.4—7.9 (11H, m). MS m/e (%): 329 (M^+, 24), 328 (M−1, 94), 313 (M−CH_3, base peak). *Anal.* Calcd for $C_{22}H_{21}ClN_2O_5+1/4\,H_2O$: C, 60.97; H, 5.00; N, 6.46. Found: C, 61.03; H, 5.04; N, 6.80.

2-Bromo-3-hydroxy-4-methyl-1-styrylpyrrolo[1,2-*a*]quinoxaline (XIIa) and Its Methyl Ether (XIIb)——Bromine was added dropwise to a suspension of VIIIa in CCl_4 until the color of bromine persisted. The mixture was stirred for 1 h, then filtered to give crude XIIa perchlorate (1.81 g). mp 249—250°C. As it was difficult to recrystallize, the corresponding free base, which was obtained by the treatment of the perchlorate with aq. NaOH (5%) solution, was methylated with excess diazomethane to give XIIb. mp 136—138°C (needles from MeOH). NMR (CCl_4): 2.73 and 3.98 (each 3H, s). MS m/e (%): 394 (M+2, 30), 392 (M^+, 30), 379 (M+2-CH_3, 15), 377 (M^+−CH_3, 15), 317 (M+2-Ph, 18), 315 (M^+−Ph, 18), 143 (methylquinoxalyl, base peak). *Anal.* Calcd for $C_{21}H_{17}BrN_2O$: C, 64.14; H, 4.36; N, 7.12. Found: C, 64.01; H, 4.24; N, 7.30.

3-Methylquinoxalin-2-yl 4-(4-nitrophenyl)-1,3-butadienyl Ketone (VIIb)——In a manner similar to that used for the preparation of VIIa, VIIb was obtained from 2-acetyl-3-methylquinoxaline (0.65 g, 3.5 mmol),

p-nitrocinnamic aldehyde (0.62 g, 3.5 mmol), and 10% aq. NaOH (0.28 ml, 0.7 mmol) in 44.6% yield. mp 236—238°C (recrystallized from benzene). IR (Nujol): $\nu_{C=O}$ 1670 (weak), ν 1590. NMR (TFA): 3.50 (3H, s, vinylic CH_3), 7.3—7.6 (2H, d), 7.6—8.2 (4H, m), 8.2—8.9 (6H, m). *Anal.* Calcd for $C_{20}H_{15}N_3O_3$: C, 69.55; H, 4.38; N, 12.17. Found: C, 69.99; H, 4.42; N, 12.41.

3-Hydroxy-4-methyl-1-(4-nitrostyryl)pyrrolo[1,2-*a*]quinoxalinium Perchlorate (VIIIb)——An ethanolic solution of VIIb (0.44 g) was refluxed in the presence of 60% $HClO_4$ (7.0 ml) for 20 h. The crystalline compound was collected on a filter and recrystallized from EtOH. The yield was 0.33 g (58.8%). mp 257—260°C (a double melting point like that of VIIIa was not observed). IR (Nujol): ν 1623, 1590. NMR (TFA): 3.10 (3H, s, vinylic CH_3), 6.99 (1H, s, C_2-H), 7.5—8.4 (6H, m), 7.92 and 8.43 (each 2H, d, J=9.5, *p*-nitrophenyl H). *Anal.* Calcd for $C_{20}H_{16}ClN_3O_6+H_2O$: C, 53.64; H, 4.05; N, 9.38. Found: C, 53.78; H, 3.76; N, 9.53.

4-Methyl-3-(4-nitrobenzoyloxy)-1-(4-nitrostyryl)pyrrolo[1,2-*a*]quinoxaline (Xb)——A 5% aq. NaOH solution (0.83 ml) was added to a mixture of VIIIb (0.15 g), *p*-nitrobenzoyl chloride (0.1 g), $CHCl_3$ (1.7 ml), and H_2O (0.3 ml) with stirring. The color of the reaction mixture turned brown-black. The separated $CHCl_3$ layer was dried and concentrated to give red-brown woolly crystals in poor yield (5 mg). mp 268—270°C. MS *m/e* (%): 494 (M^+, 0.2), 373 (M^+-nitrophenyl, 28), 344 (M^+-*p*-nitrobenzoyl, 27), 143 (methylquinoxalyl, base peak).

2-Hydroxyl-2-phenylethyl 2[1*H*]-pyrrolyl Ketone (XVa)——A 10% aq. NaOH solution (1.2 ml, 2.9 mmol) was added dropwise to an ethanolic solution of 2-acetylpyrrole (1.6 g, 14.4 mmol) and benzaldehyde (1.5 g, 14.4 mmol). After being stirred for 1 h at room temperature, the reaction mixture was diluted with H_2O and extracted with benzene. The organic layer was dried, and the benzene was removed to give an oily material, which was separated through SiO_2 column chromatography from benzene. From the earlier eluate, 2-acetylpyrrole (0.91 g) and XVa (0.52 g; the conversion yield was 39.9%) were obtained successively. XVa: mp 98—102°C (recrystallized from EtOH). IR ($CDCl_3$): $\nu_{C=O}$ 1630. NMR ($CDCl_3$: 3.16 (2H, d, J=7, $>CH_2$), 4.04 (1H, br s, OH), 5.26 (1H, t, J=7, $>C\underline{H}(OH)$), 6.25 (1H, m, C_4-H), 6.95 (2H, m, $C_{3,5}$-H), 7.26 (5H, s). *Anal.* Calcd for $C_{13}H_{13}NO_2$: C, 72.54; H, 6.09; N, 6.51. Found: C, 72.64; H, 6.12; N,6.54.

2-Acetoxy-2-phenylethyl 2[1*H*]-pyrrolyl Ketone (XVb)——A mixture of XVa (0.19 g), pyridine (5ml), and Ac_2O (2ml) was refluxed for 1 h. The cooled mixture was poured into ice-water, and extracted with ether. The ether layer was washed with 5% HCl, sat. $NaHCO_3$, and brine, then dried. The residue obtained after removal of the solvent was fractionated through an SiO_2 column. The second benzene eluate gave XVb as an oily substance. The yield was 58.8%. NMR (CCl_4): 1.90 (3H, s, $-COCH_3$), 3.10 (1H, dd, J=16, 5.5, $>C\underline{H}(H)$), 3.56 (1H, dd, J=16, 9, $>CH(\underline{H})$), 6.40 (1H, dd, J=9, 5.5, $>C\underline{H}$-OAc), 6.2 (1H. m, C_4-H), 6.9 (1H, m, C_3- or C_5-H), 7.1 (1H, m, C_3- or C_5-H), 7.30 (5H, s, aromatic H). MS *m/e* (%): 257 (M^+, 23), 214 (M−Ac, 75), 94 (pyrrolyl ketone, base peak).

Further elution with benzene gave 2-cinnamoyl-[1*H*]pyrrole (XIV)[2] in 11.4% yield. XIV: mp 139—142°C (recrystallized from CCl_4). *Anal.* Calcd for $C_{13}H_{11}NO$: C, 79.16; H, 5.62; N, 7.10. Found: C,78.92; H, 5.69; N, 7.04. XIV could be obtained by means of micro-distillation of XVb in 63.4% yield.

References and Notes

1) *a*) Part I: K. Matoba, K. Itoh, K. Kondo, T. Yamazaki, and M. Nagata, *Chem. pharm. Bull.*, **29**, 2442 (1981); *b*) A part of this work was presented at the 102nd Annual Meeting of the Pharmaceutial Society of Japan, April 1982, Oosaka.
2) K. Matoba and T. Yamazaki, *Chem. Pharm. Bull.*, **30**, 2586 (1982).
3) J.M. Wefer, A. Catala, and F.D. Popp, *J. Org. Chem.*, **30**, 3075 (1965).
4) F.W. Kröck and F. Kröhnke, *Chem. Ber.*, **104**, 1629 (1971).
5) P. Piutti, *Gazz. Chim. Ital.*, **66**, 276 (1936) [*Chem. Abstr.*, **31**, 1768[4] (1937)].