A Simple Method for the Synthesis of 2,3-Bis(arylazo)quinoxalines

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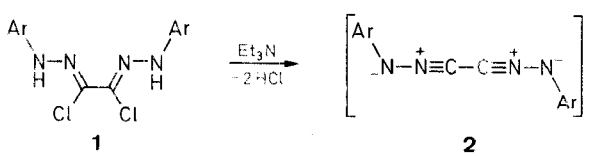
The first synthesis of the novel 2,3-bis(arylazo)quinoxalines in high overall yields proceeds via reaction of 1,2-phenylenediamines with *N,N'*-diarylethanedihydrazonoyl dichlorides in the presence of triethylamine and oxidation of the resultant 2,3-bis(arylhydrazono)-1,2,3,4-tetrahydroquinoxalines.

Quinoxaline derivatives have attracted interest as biologically active materials[1] and they find considerable application as reactive dyes, cyanine dyes, fluorescent dyes, and pigments.[2] Renewed interest in the azo dyes is due to their use as materials having nonlinear optical properties.[3,4] The active components in these materials consist of conjugated systems bearing both an electron donor and an electron acceptor as terminal groups.

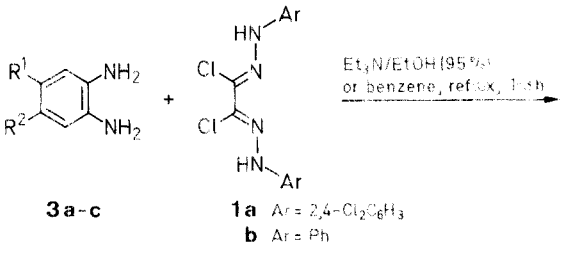
We now report the first synthesis of 2,3-bis(arylazo)quinoxalines **5** by a simple procedure, which uses easily available starting materials and affords good overall yields. While the synthesis of several 2-arylazoquinoxaline derivatives has been reported,[5,6] 2,3-bis(arylazo)quinoxalines hitherto are unknown.

It has been reported[7] that the readily available *N,N'*-diarylethanedihydrazonoyl dichlorides **1** (1,2-dichloroglyoxal bis-arylhydrazones) are converted by triethylamine into oxalodinitrile bis(arylimines) **2**, which are reactive intermediates that cannot be isolated but which undergo 1,3-dipolar cycloadditions with suitable dipolarophiles.

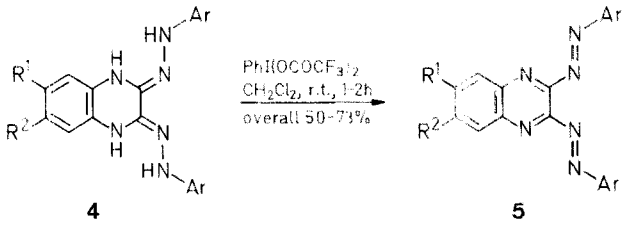


1 **2**

We find that oxalodinitrile bis(arylimines) **2** also react with 1,2-phenylenediamines **3** affording high yields of 2,3-bis(arylhydrazono)-1,2,3,4-tetrahydroquinoxalines **4**. Upon heating *N,N'*-bis(2,4-dichlorophenyl)ethanedihydrazonoyl dichloride (**1a**) and 1,2-phenylenediamines **3a,b,c** in ethanol in the presence of excess triethylamine for 3 h, the respective 2,3-bis(2,4-dichlorophenylhydrazono)-1,2,3,4-tetrahydroquinoxalines **4aa**, **4ab**, and **4ac** were precipitated from the ethanolic solution as red microcrystals in high 75–90% yields and in very pure form; further purification was not necessary. Their oxidation with iodobenzene bis(trifluoroacetate) afforded 2,3-bis(2,4-dichlorophenylazo)quinoxalines **5aa**, **5ab** and **5ac**, respectively, in 77–84% yields (overall yields 62–73%).



3a–c **1a** Ar = 2,4-$Cl_2C_6H_3$
b Ar = Ph



4 **5**

3	R^1	R^2
a	H	H
b	Me	H
c	Me	Me

4, 5	Ar	R^1	R^2
aa	2,4-$Cl_2C_6H_3$	H	H
ab	2,4-$Cl_2C_6H_3$	CH_3	H
ac	2,4-$Cl_2C_6H_3$	CH_3	CH_3
ba	Ph	H	H
bb	Ph	CH_3	H
bc	Ph	CH_3	CH_3

The bis(phenylhydrazones) **4ba**, **4bb**, and **4bc** generated from *N,N'*-diphenylethanedihydrazonoyl dichloride (**1b**) were not stable under the same conditions (boiling 95% ethanol) but were oxidized by atmospheric oxygen to 2,3-bis(phenylazo)quinoxalines **5ba**, **5bb**, and **5bc**, respectively, which were isolated by column chromatography in relatively low yields (10–23%) together with a variety of by-products. The use of benzene as solvent instead of 95% ethanol gave the bis-phenylhydrazones **4ba**, **4bb**, and **4bc**, which under these conditions were found to be more stable. However, attempts to isolate these products chromatographically in pure form failed, the bis(hydrazones) **4** being oxidized on the column to the respective azo compounds **5**. The reaction mixture containing the bis-phenylhydrazones **4ba**, **4bb**, or **4bc** in benzene solution was therefore simply refluxed for 1 h; then, iodobenzene bis(trifluoroacetate) was added to oxidize

compounds **4** to the corresponding 2,3-bis(phenylazo)quinoxalines **5ba**, **5bb**, and **5bc**, respectively, in good overall yields (50–54%).

The structure of the isolated compounds **4** and **5** were established from their microanalyses and spectra data (MS, UV/Vis, IR, ^{1}H- and ^{13}C-NMR), which are given in Tables 1

Table 1. Compounds **4** and **5** Prepared

Product	Yield[a] (%)	mp (°C) (solvent)	Molecular Formula[b]	MS (70 eV) *m/z* (%)	IR (Nujol) ν (cm^{-1})	UV/VIS (THF) λ_{max} (nm) (log ε)	^{1}H-NMR ($CDCl_3$/TMS) δ, *J* (Hz)
4aa	75	202–204 (EtOH)[c]	$C_{20}H_{14}Cl_4N_6$ (480.2)	482/480/478 ($M^+ + 4/M^+ + 2/M^+$);[e] 319 (3); 317 (18); 315 (25); 165 (10); 163 (68); 161 (100)	3350, 3310, 3080, 1650, 1620, 1590, 1550	300 (4.09); 366 (4.12); 462 (3.68)	–[d]
4ab	80	199–200 (EtOH)[c]	$C_{21}H_{16}Cl_4N_6$ (494.2)	333 (4); 331 (22); 329 (40); 165 (11); 163 (66); 161 (100)	3340, 3300, 3080, 1620, 1575, 1550	305 (4.13); 377 (4.19); 466 (3.75)	–[d]
4ac	90	195–196 (dec) (EtOH)[c]	$C_{22}H_{18}Cl_4N_6$ (508.2)	510/508/506 ($M^+ + 4/M^+ + 2/M^+$);[e] 347 (1); 345 (5); 343 (7); 165 (11); 163 (66); 161 (100)	3340, 3280, 3060, 1655, 1630, 1590	305 (4.31); 376 (4.35); 476 (3.85)	–[d]
5aa	84[f]	206–208 ($CHCl_3$/hexane)	$C_{20}H_{10}Cl_4N_6$ (476.2)	478/476/474 ($M^+ + 4/M^+ + 2/M^+$);[e] 319 (1); 317 (4); 315 (5); 283 (4); 281 (11); 268 (11); 266 (25); 150 (12); 148 (66); 146 (100)	3060, 1570	318 (4.51)	7.3 (dd, 2H, *J* = 2, 9, H-5′); 7.6 (d, 2H, *J* = 2, H-3′); 7.7 (d, 2H, *J* = 9, H-6′); 7.9, 8.3 (m, ABA′B′, 4H, H-5, H-6, H-7, H-8)
5ab	77	229–232 ($CHCl_3$/hexane)	$C_{21}H_{12}Cl_4N_6$ (490.2)	492/490/488 ($M^+ + 4/M^+ + 2/M^+$);[e] 464 (1); 462 (1); 460 (1); 428 (1); 426 (2); 424 (2); 333 (1); 331 (3); 329 (4); 282 (13); 280 (31); 150 (13); 148 (66); 146 (100)	3060, 1570	318 (4.50)	2.7 (s, 3H, CH_3); 7.3 (dd, 2H, *J* = 2, 9, H-5′); 7.6 (d, 2H, *J* = 2, H-3′); 7.7 (d, 2H, H-6′); 7.8 (dd, 1H, *J* = 2, 9, H-7); 8.1 (d, 1H, *J* = 2, H-5); 8.2 (d, 1H, *J* = 9, H-8)
5ac	81	221–223 ($CHCl_3$/hexane)	$C_{22}H_{14}Cl_4N_6$ (504.2)	506/504/502 ($M^+ + 4/M^+ + 2/M^+$);[e] 478 (2); 476 (4); 474 (3); 443 (4); 441 (10); 439 (10); 347 (3); 345 (17); 343 (23); 334 (4); 332 (30); 330 (47); 296 (33); 294 (77); 165 (19); 163 (31); 161 (54); 150 (31); 148 (60); 146 (100)	3080, 1580	320 (4.54)	2.6 (s, 6H, $2CH_3$); 7.3 (dd, 2H, *J* = 2, 9, H-5′); 7.6 (d, 2H, *J* = 2, H-3′); 7.7 (d, 2H, *J* = 9, H-6′); 8.1 (s, 2H, H-5, H-8)
5ba	54[g]	110–113[h] (EtOH)	$C_{20}H_{14}N_6$ (338.4)	338 (M^+, 4); 310 (2); 247 (31); 105 (15); 77 (100)	3060, 1590	301 (4.34); 340sh (4.19)	7.6 (m, 6H); 8.1 (m, 8H)
5bb	50[g]	103–106[h] (EtOH)	$C_{21}H_{16}N_6$ (352.4)	352 (M^+, 1); 326 (1); 261 (37); 105 (15); 93 (100); 77 (45)	3060, 1590	304 (4.52); 342sh (4.34)	2.6 (s, 3H, CH_3); 7.6 (m, 6H); 8.1 (m, 7H)
5bc	53[g]	151–154[h] (EtOH)	$C_{22}H_{18}N_6$ (366.4)	366 (M^+, 33); 338 (15); 337 (15); 275 (22); 105 (72); 77 (100)	3040, 1580	305 (4.48); 343sh (4.31)	2.5 (s, 6H, $2CH_3$); 7.6 (m, 6H); 8.1 (m, 6H)

[a] Yield of isolated products **4** and **5** based on **1**.
[b] Satisfactory microanalyses: C ±0.26, H ±0.26, N ±0.34.
[c] Not recrystallized, precipitated from the ethanolic reaction solution.
[d] Insoluble to the usual NMR solvents.
[e] Peaks of very low intensity.
[f] Use of $Pb(OAc)_4$ afforded **5aa** in 7[illegible]% yield, while H_2O_2 did not oxidize **4aa**.
[g] Overall yield based on **1**.
[h] Upon fast heating.

Table 2. ^{13}C-NMR ($CDCl_3$/TMS) Chemical Shifts δ of 1,2-Bis(arylazo)quinoxalines **5**

Compound	C-2 C-3	C-4a C-8a	C-5 C-8	C-6 C-7	C-1′	C-2′	C-3′	C-4′	C-5′	C-6′	CH_3
5aa	152.1	141.6	131.9[a]	130.1[a]	147.6	138.0	130.8	139.5	127.8	118.7	–
5ab	151.4	140.0	128.8	134.3	147.6	138.0	130.7	139.3	127.8	118.7	22.2
	152.1	141.7	129.6	143.1							
5ac	151.6	140.6	129.0	143.1	147.6	137.8	130.7	139.2	127.7	118.7	20.6
5ba	152.8	141.7	131.3[a]	130.1[a]	153.0	123.9	129.2	132.9	–	–	–
5bb	152.0	140.2	128.9	133.8	153.0	123.9	129.2	132.8	–	–	22.0
	152.8	141.8	129.6	142.4							
5bc	152.2	140.7	129.2	142.5	153.0	123.9	129.2	132.7	–	–	20.6

[a] Assignments could be interchanged.

and 2. For the bis-hydrazones **4aa, 4ab**, and **4ac**, NMR spectra have not been obtained due to their insolubility in the usual NMR solvents. Table 2 records the ^{13}C-NMR spectra of bis(arylazo)quinoxalines **5**. The shift assignments were done by using the known quinoxaline spectral shifts[8] and substituent chemical shifts.[9]

In conclusion, the reactions described here afford very good overall yields of the novel bis(arylazo)quinoxalines **5** while the intermediates need not always be isolated. On considering the electron deficiency[8] of the 2-quinoxalinyl group attached to the azo group, this deficiency being further increase by the presence of the second arylazo group, it seems that suitable substitution in the 4-position of the phenyl rings in the starting material[7] **1** by an electron-donating substituent of the right length, could provide azo compounds useful as compounds having nonlinear optical properties. Compounds **5** themselves also might be of interest as dyestuffs.

1,2-Phenylenediamine, 4-methyl-1,2-phenylenediamine, and 4,5-dimethyl-1,2-phenylenediamine were purchased from Fluka Chemical Co. and were used without further purification. Iodobenzene bis(trifluoroacetate),[10] *N,N'*-diphenyl-(**1b**)[7] and *N,N'*-bis(2,4-dichlorophenyl)ethanedihydrazonoyl dichloride (**1a**)[11] were prepared according to literature methods. Melting points are uncorrected and were determined on a Kofler hot-stage microscope. Microanalyses were performed on a Perkin-Elmer 240B element analyser. Mass spectra were recorded on a Hitachi-Perkin Elmer RMU-6L spectrometer at 70 eV. IR spectra were obtained on a Perkin-Elmer 297 Infrared spectrophotometer and UV/Vis spectra on a Shimadzu UV-210A spectrophotometer. ^{1}H-NMR spectra were recorded at 60 MHz on a Varian A60-A spectrometer and ^{13}C-NMR spectra at 20 MHz on a Varian CFT-20 spectrometer.

2,3-Bis(2,4-dichlorophenylhydrazono)-1,2,3,4-tetrahydroquinoxalines 4aa, 4ab, and 4ac; General Procedure:

A suspension of *N,N'*-bis(dichlorophenyl)ethanedihydrazonoyl dichloride (**1a**; 890 mg, 2 mmol), the 1,2-phenylenediamine **3a–c** (2.2 mmol, 1.1 equiv), and Et_3N (1 mL) in 95% EtOH (20 mL) is refluxed for 3 h and then allowed to stand at room temperature overnight. The precipitated red microcrystals are isolated by suction, washed with H_2O (20 mL), and dried in vacuo to give analytically pure product **4**.

2,3-Bis(2,4-dichlorophenylazo)quinoxalines 5aa, 5ab, and 5ac; General Procedure:

To a magnetically stirred suspension of hydrazones **4aa, 4ab**, or **4ac** (1 mmol) in CH_2Cl_2 (20 mL), a solution of iodobenzene bis(trifluoroacetate) (860 mg, 2 mmol, 2 equiv) in CH_2Cl_2 (10 mL) is added, and stirring is continued at room temperature for 2 h. The solvent is evaporated, and the residue is column chromatographed on silica gel using CH_2Cl_2 as eluent to give, at first, iodobenzene (89–94%) and then the bis(arylazo)quinoxaline **5**.

2,3-Bis(phenylazo)quinoxalines 5ba, 5bb, and 5bc; General Procedure:

A suspension of *N,N'*-diphenylethanedihydrazonoyl dichloride (**1b**; 307 mg, 1 mmol), the 1,2-phenylenediamine **1a–c** (1.1 mmol, 1.1 equiv), and Et_3N (0.5 mL) in benzene (10 mL) is refluxed for 1 h and then allowed to stand at room temperature for 2 h. The mixture is further partitioned between CH_2Cl_2 (50 mL) and H_2O (50 mL), and the organic layer is separated and dried (Na_2SO_4). A solution of iodobenzene bis(trifluoroacetate) (860 mg, 2 mmol, 2 equiv) in CH_2Cl_2 (10 mL) is added and the mixture is allowed to stand at room temperature for 1 h. The solvent is evaporated and the oily residue is column chromatographed on silica gel using CH_2Cl_2 as eluent to give, at first, iodobenzene (65–78%) and then the desired compounds **5**.

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(1) Cheeseman, G.W.H., Werstiuk, E.S.G. *Adv. Heterocycl. Chem.* **1978**, *22*, 367.
(2) Phodke, R.C., Raugnekar, D.W. *Bull. Chem. Soc. Jpn.* **1986**, *59*, 1245, and references therein.
(3) Katz, H.M., Singer, K.D., Sohn, J.E., Dirk, C.W., King, L.A., Gordon, H.M. *J. Am. Chem. Soc.* **1987**, *109*, 6561.
(4) Schilling, M.L., Katz, H.E., Cox, D.I. *J. Org. Chem.* **1988**, *53*, 5538, and references therein.
(5) Parkanyi, C., Abdelhamid, A.O., Shawali, A.S. *J. Heterocycl. Chem.* **1984**, *21*, 521.
(6) Krieger, C., Kocak, A., Becaroglu, O. *Helv. Chim. Acta* **1985**, *68*, 581.
(7) Grundmann, C., Datta, S.K., Sprecher, R.F. *Liebigs Ann. Chem.* **1971**, *744*, 88.
(8) Porter, A.E.A., in: *Comprehensive Heterocyclic Chemistry*, Vol. 3, Katritzky, A.R., Rees, C.W. (eds.), Pergamon Press, Oxford, 1984, p. 157.
(9) Ewing, D.F. *Org. Magn. Reson.* **1979**, *12*, 499.
(10) Spyroudis, S., Varvoglis, A. *Synthesis* **1975**, 445.
(11) Chattaway, F.D., Farinhold, L.H. *J. Chem. Soc.* **1930**, 94.