cal properties of the synthesized 2-aminothiazoles are summarized in Table II. Some derivatives of 2-aminothiazoles were prepared by the method of Shriner et al. *(12)* and are listed in Table II.

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Synthesis and Spectral Data For Quinoxaline Derivatives

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Thirteen quinoxaline derivatives were synthesized by the interaction of *o*-phenylenediamine with either α-bromoketones or the glyoxal derivatives of the corresponding methylketones. The uv, ir, and nmr spectral data for the quinoxaline derivatives obtained are presented.

Thirteen quinoxaline derivatives were prepared by the interaction of *o*-phenylenediamine with either α-bromoketones (Method A) *(3, 10, 11)*, or the glyoxal derivatives of the corresponding methylketones (Method B) *(6)*. The α-bromoketones used were: 2-bromoacetylfluorene, *p*-hydroxyphenacylbromide, *p*-nitrophenacylbromide, 2-bromo-1-tetralone, 3-bromoacetoacetic ester, 5-bromoacetylindane, 3-bromoacetylindol, and 2-bromo-7-nitro-1-tetralone. The ketones used in Method B were: *p*-hydroxyacetophenone, 7-nitro-1-tetralone, 2-acetylthiophene, 2-acetylfuran, and α-, β-, and γ-acetylpyridines. The structure and physical properties of the synthesized quinoxalines are given in Table I. The uv, ir, and nmr spectral data are presented in Tables II and III.

Dihydroquinoxaline, which is the primary condensation product, is so readily oxidized to the corresponding quinoxaline that it is not isolated under the standard conditions *(7)*. In Method B, the ketones were oxidized to the corresponding glyoxal derivative with selenium dioxide in dioxane solution. It was not attempted in this study to

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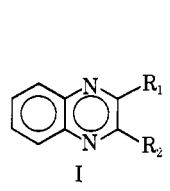
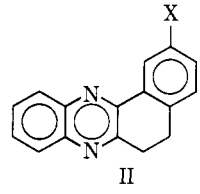
Table I. Physical Properties of Quinoxaline Derivatives[a]



I



II

	Molecular formula	R_1 (or X)	R_2	Mp, °C	% Yield Method A	% Yield Method B	Ref. time	Crystn solvent	4-N-oxide mp, °C (crystn solvent)
I_a	$C_{21}H_{14}N_2$	2-fluorenyl	H	200–201[b]	75		5	Ethanol	
I_b	$C_{14}H_{10}N_2O$	C_6H_4·OH(p)	H	209–210[c]	68	73	2	Benzene	234–235 (Benzene)
I_c	$C_{14}H_{19}N_3O_2$	C_6H_4·NO_2(p)	H	189–190[d]	60		4	Ligroin (bp 120)	267–268 (Acetic acid)
I_d	$C_{12}H_{12}N_2O_2$	CH_3	CO_2Et	70–71[e]	25		8	Water	
I_e	$C_{17}H_{14}N_2$	5-Indanyl	H	116–117	50		4	Methanol	
I_f	$C_{16}H_{11}N_3$	3-Indolyl	H	208–209[f]	60		4	Acetic acid	
I_g	$C_{12}H_8N_2S$	2-Thienyl	H	120–121[g]	55	65	5	Methanol	
I_h	$C_{13}H_9N_3$	α-Pyridyl	H	113–114[h]		60	5	Methanol	
I_i	$C_{13}H_9N_3$	β-Pyridyl	H	243–244		55	5	Methanol	
I_j	$C_{13}H_9N_3$	γ-Pyridyl	H	255–256		45	6	Methanol	
I_k	$C_{12}H_8N_2O$	2-Furyl	H	101–102[i]		72	5	Methanol–water	
II_a	$C_{16}H_{12}N_2$	H	...	152–153[j]	55		4	Ligroin (bp 40–60)	
II_b	$C_{16}H_{11}N_3O_2$	NO_2	...	300–301	65	75	2	Acetic acid	

[a] Elemental analyses (C,H,N) in agreement with theoretical values were obtained and submitted for review. [b] Ref. 9. mp 193°C. [c] Ref. 8. mp 204°C. [d] Ref. 3. 4. mp 187–188°C. [e] Ref. 1. mp 73°C. [f] Ref. 14. mp 202–203. [g] Ref. 5. mp 117–119°C. [h] Ref. 16. mp 112–114°C. [i] Ref. 6. mp 101°C. [j] Ref. 13. 152.5°C.

Table II. Ir and Uv Absorption Data For Quinoxaline Derivatives[a]

	Ring stretching vibrations	C—H in-plane deformation	C—H out-of-plane deformation	λ_{max} (mμ) log ε	Other bands
I_a	1695(s), 1625(m), 1575(m), 1380(s), 1367(s), 1300(s)	1267(s), 1230(m), 1155(m), 1100(w), 1025(w), 1000(m)	955(s), 900(m), 860(m), 775(s), 740(s), 685(w)	208 (4.56)	238, 270, 343
I_b	1620(s), 1610(s), 1595(s), 1550(s), 1525(s), 1495(s), 1415(w), 1343(m), 1325(s), 1275(s)	1245(s), 1233(s), 1210(w), 1170(s), 1145(m), 1135(m), 1110(w), 1157(m), 1115(w)	970(s), 955(m), 935(m), 880(m), 840(s), 790(m), 770(m), 760(s), 732(m), 680(m), 665(m), 618(w)	213 (4.34)	245, 260, 283, 355
I_c	1600(m), 1525(s), 1345(s)	1217(w), 1138(m), 1118(m), 1100(m), 1015(m)	960(m), 920(m), 865(s), 850(s), 825(w), 788(s), 756(w), 725(m)	203 (4.49)	239, 273, 323
I_e	1600(m), 1555(m), 1317(m)	1300(m), 1155(w), 1130(w), 1095(w), 1040(m)	972(s), 955(m), 935(w), 885(m), 852(m), 758(s), 707(m)	209 (4.47)	252, 329
I_f	1567(s), 1300(m)	1245(m), 1175(m), 1136(m), 1015(w), 1000(w)	950(m), 760(s), 750(s), 725(w)	204 (4.45)	223, 346
I_g	1580(m), 1550(s), 1495(m), 1430(s), 1340(w), 1325(s), 1315(m), 1280(w), 1240(m)	1210(m), 1137(m), 1130(m), 1075(m), 1055(s), 1020(w), 1000(m)	960(s), 945(m), 930(m), 910(m), 865(m), 855(m), 840(w), 760(s), 725(s), 680(m), 620(m), 590(m)	218 (4.36)	273, 353
I_h	1595(m), 1553(m), 1495(m), 1405(m), 1370(m), 1340(w), 1325(w), 1275(w)	1135(m), 1100(w), 1060(s), 1045(s), 1000(m)	965(s), 930(m), 880(m), 810(s), 790(s), 770(s), 740(s), 720(m), 670(m), 630(m), 615(m), 580(w)	211 (4.18)	251, 275, 333
I_b'[b]	1540(m), 1500(w), 1384(s), 1365(s)	1290(s), 1250(s), 1220(s), 1196(m), 1175(m), 1135(m)	930(s), 875(m), 840(s), 775(s), 732(w)	301 (4.97)	210, 354
II_b	1515(m), 1345(s)	1165(m), 1120(m), 1086(m)	935(m), 898(s), 860(s), 805(m), 775(s), 760(s), 745(m)	253 (4.44)	209, 260, 304, 363
I_c'[c]				282 (4.24)	202, 236, 324

[a] s = strong, m = medium, w = weak. [b] I_b' = I_b 4-N-oxide. [c] I_c' = I_c 4-N-oxide.

isolate and characterize the glyoxal derivatives; they were used directly in the condensation with *o*-phenylenediamine. A comparison of the yields in these two methods shows that Method B gives better yield and pure products.

Oxidation of quinoxaline derivatives to N-oxides was carried out according to the method of Clemo and McIlwain *(4)* with hydrogen peroxide and glacial acetic acid. These oxides were regarded as 4-N-oxides owing to the steric hindrance obtained for the attachment of oxygen atom to the nitrogen at 1-position, which is adjacent to the bulky aryl groups *(12)*.

The uv absorption spectra of quinoxaline derivatives (I_a–I_g), listed in Table II, showed a hypsochromic shift in comparison with the parent compound (quinoxaline), which had absorption maxima at 233 and 315 mμ *(2)* while the other compounds (II_b, I_b', and I_c') showed marked bathochromic shifts. The bathochromic shifts in the two N-oxides were probably due to the hydrogen bonding interactions with the negative oxide ion *(17)*.

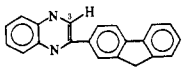
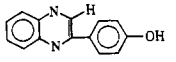
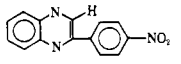
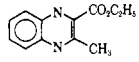
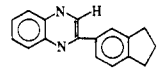
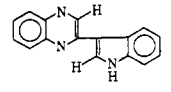
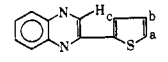
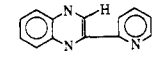
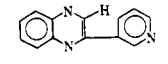
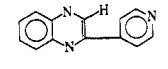
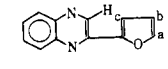
Characteristic aromatic ring vibrations appeared in the ir spectra of quinoxalines in the region 1600–1350 cm^{-1}. The position and intensity of these vibrations were dependent on the nature of the substituent. The investigated compounds showed three to four strong-to-medium intensity bands in this region.

The $N^+—O^-$ stretching frequency in N-oxides occurred at 1300–1200 cm^{-1} *(15)*, but within this range the frequency was increased by the presence of electron-accepting substituents in the ring. N-oxides showed another characteristic band near 850 cm^{-1}, which might be due to the $N^+—O^-$ in-plane bonding mode *(18)*.

Experimental

Melting points were determined on a Kofler Hot Bench and are uncorrected. Elemental analyses were performed by Alfred Bernhardt Laboratories, Ruhr, Germany. Uv absorption spectra were measured as solutions in ethanol

Table III. Nmr Data for Quinoxaline Derivatives[a]

	Structure	Solvent	Aliphatic-H	Aromatic-H	H-3	J_{ab}, J_{bc}, J_{ac}, Hz
Ia		TFA	5.87bs, CH_2	2.35m, 1.5m	−0.15s	
Ib		TFA	6.8s, OH	1.6m, 2.5d	−0.10s	8.5
Ic		TFA		1.32m, 1.46d, 1.2d	−0.10s	7.5
		DMSO		2.1m, 1.7d, 1.4d	0.40s	8.5
Id		TFA	8.36t, 5.1q 6.5s	1.5m, 2.15m		
Ie		TFA	7.65qn, 6.8t	2.27d, 1.85d, 1.47m	−0.33s	8
If		DMSO	1.07d, NH 1.22d, =CH	2.07m, 2.47m	0.33s	4
Ig		DMSO		2.16m, 2.95dd, 2.42d, 2.35d	0.35s	4.5, 3.5, 1.7
Ih		DMSO		2.01m, 0.83m	0.12	
Ii		DMSO		2.07m, 0.7m, 0.3d, 1.45m	0.15	
Ij		DMSO		2.12m, 1.2d, 0.7d	0.18	6
Ik		DMSO		2.1m, 2.18d, 3.18d, 3.33dd	0.31s	3.5, 1.6, 1.5

[a] s = singlet, bs = broad singlet, d = doublet, t = triplet, q = quartet, qn = quintet, m = multiplet, J_{ab}, J_{bc}, J_{ac} = coupling constants in all AB or ABC systems, TFA = trifluoroacetic acid, DMSO = deuterated dimethylsulfoxide.

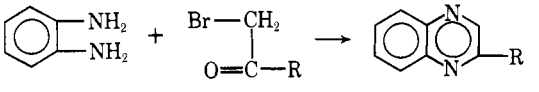
by a Unicam SP800B uv spectrophotometer. Ir absorption spectra were recorded on a Beckman IR 12 spectrophotometer as Nujol mulls. Nmr spectra were measured on a Varian A60A spectrometer as solutions in deuterated dimethylsulfoxide (DMSO-d_6), or trifluoroacetic acid (TFA), with tetramethylsilane (TMS) as internal reference.

General procedures for preparation of quinoxaline derivatives. *Method A.* o-Phenylenediamine (0.1 mole) in ethanol or glacial acetic acid (500 ml), was mixed with the α-bromoketone (0.1 mole), in ethanol (100 ml). The mixture was refluxed for several hours (Table I), the solvent was evaporated to half its volume under reduced pressure, decolorized with charcoal, and left to cool to room temperature. Recrystallization of the product from a suitable solvent (Table I) gave the pure quinoxaline derivatives. Physical constants, yields, reaction conditions, and solvents of recrystallization for the synthesized quinoxalines are given in Table I.

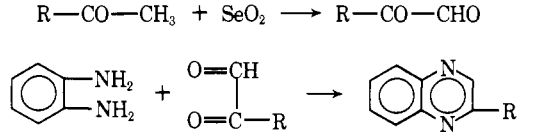
Method B. The ketone (0.03 mole) was added to a solution of selenium dioxide (0.024 mole) in dioxane (20 ml; 90%). The mixture was refluxed for 4 hr and filtered from the precipitated selenium metal. o-Phenylenediamine (0.03 mole) was added to this solution and refluxed for 15 min. The reaction mixture was diluted with water, cooled, and filtered. Recrystallization of the product afforded the pure quinoxaline derivative.

Preparation of quinoxaline N-oxide. The quinoxaline (1 gram) in glacial acetic acid (50 ml) and hydrogen peroxide (5 ml; 30%) were heated at 50°C for 12 hr. The solution was diluted with water and cooled. The N-oxide separated as fine orange needles. Melting points and solvents of recrystallization are given in Table I.

Method A



Method B



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