Ring Contraction of 2-Azidoquinoline and Quinoxaline 1-Oxides[1]

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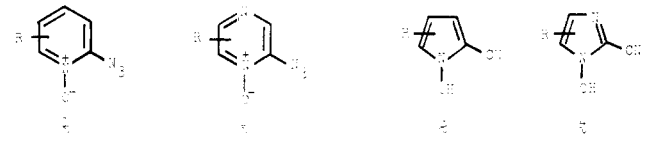
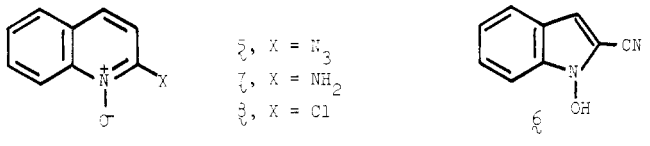
Thermal ring contraction of 2-azidoquinoline 1-oxide with loss of nitrogen did not lead to the desired 2-cyano-1-hydroxyindole. Instead, 2-cyanoisatogen (**9**), 2,2′-dicyano-3,3′-bis[indole] (**10**), and 2-aminoquinoline 1-oxide (**7**) were formed. The mechanism is believed to involve an intermolecular addition to the intermediate *cis*-*o*-nitrosocinnamonitrile formed in a concerted ring-opening nitrogen loss, i.e., not involving a nitrene intermediate. In accord with this, both 2-azido-4-methylquinoline 1-oxide and 2-azidoquinoxaline 1-oxide give the expected 2-cyano-1-hydroxy-3-methylindole (**18**) and 2-cyano-1-hydroxybenzimidazole (**26**), respectively.

The thermal decomposition of 2-azidopyridine 1-oxides (**1**, R = H) and 2-azidopyrazine 1-oxides (**2**) led to the



formation of 2-cyano-1-hydroxypyrroles (**3**) and 2-cyano-1-hydroxyimidazoles (**4**), respectively.[2] 2-Azidoquinoline 1-oxide (**5**) should undergo a similar ring contraction leading to the desirable 2-cyano-1-hydroxyindole (**6**).



5, X = N_3
7, X = NH_2
8, X = Cl

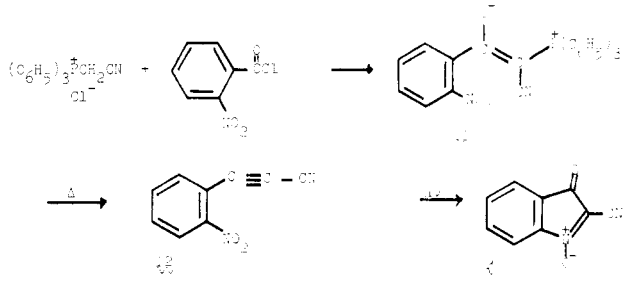
Examination of the literature revealed that **5** had been prepared and its thermal decomposition in alcohol studied,[3] but 2-aminoquinoline 1-oxide (**7**) was the only product reportedly detected. Furthermore, **5** was said to be relatively stable since it was prepared from 2-chloroquinoline 1-oxide (**8**) and sodium azide in boiling alcohol.

Repetition of the literature procedure afforded only a low yield of **5** along with **7**, but, in addition, two products containing a cyano group were detected. Since **5** apparently underwent extensive decomposition under the reaction conditions reported, its preparation under milder conditions was investigated. Treatment of 2-chloroquinoline 1-oxide with excess sodium azide in aqueous acetone containing a small amount of concentrated hydrochloric acid for 72 h at room temperature afforded **5** in 58% yield.

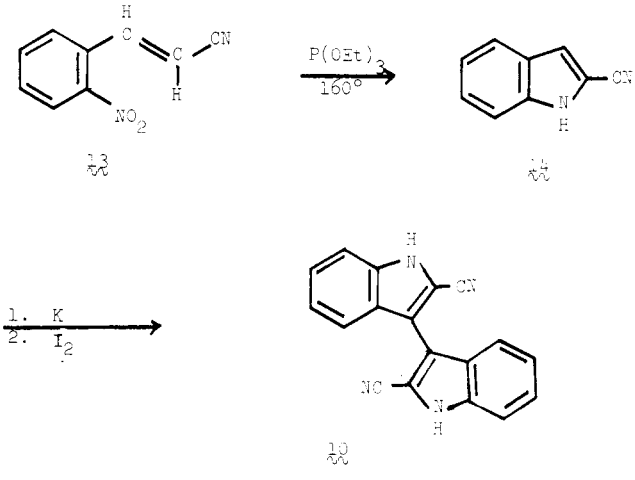
When **5** was heated in degassed toluene at 100 °C for 15 min, it decomposed completely. When the mixture cooled, **7** (21%), identical with an authentic sample,[4] precipitated. The two nitrile-containing products were isolated by careful column chromatography of the residue obtained by evaporation of the filtrate. Neither compound exhibited the spectral or chemical properties expected of the *N*-hydroxyindole **6**.

On the basis of its spectral properties and an unambiguous synthesis, the first compound which eluted was characterized as 2-cyanoisatogen (**9**), a bright red solid, mp 200 °C dec. The synthesis of authentic **9** is depicted in Scheme I. Condensation of (cyanomethyl)triphenylphosphonium chloride[5] with *o*-nitrobenzoyl chloride in benzene according to Gough and Trippett[6] gave an 87% yield of triphenylphosphonium α-cyano-*o*-nitrophenacylide (**11**). Pyrolysis of **11** at 265 °C (5 mm) gave *o*-nitrophenylpropiolonitrile (**12**) as a rather unstable yellow oil (18% yield). This underwent photochemical cyclization in benzene with 3000-Å radiation to give 2-cyanoisatogen (**9**) in 48% yield. In the infrared spectrum of **9**, strong absorptions were observed at 2230 (C≡N), 1710 (C=O), and 1520 cm^{-1} (N^+–O^-). The carbonyl stretching frequency for 2-phenylisatogen is observed at 1710 cm^{-1}.[7] The mass spectrum of **2** exhibited a molecular ion at *m/e* 172 which ejected CO as the principal mode of fragmentation to give an ion at *m/e* 144. An ion at *m/e* 156 (M^+ - O) was also recorded.

Scheme I



Scheme II



The other ring-contraction product (obtained in 22% yield) was identified as 2,2′-dicyano-3,3′-bis[indole] (**10**) on the basis of its spectral properties, elemental analysis, and a synthesis of authentic **10** (Scheme II). Heating

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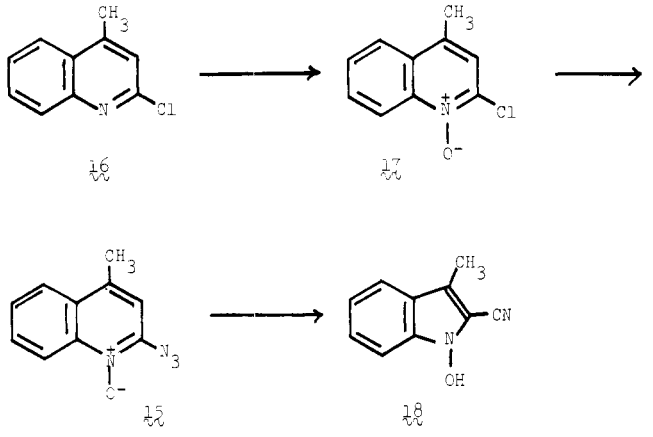
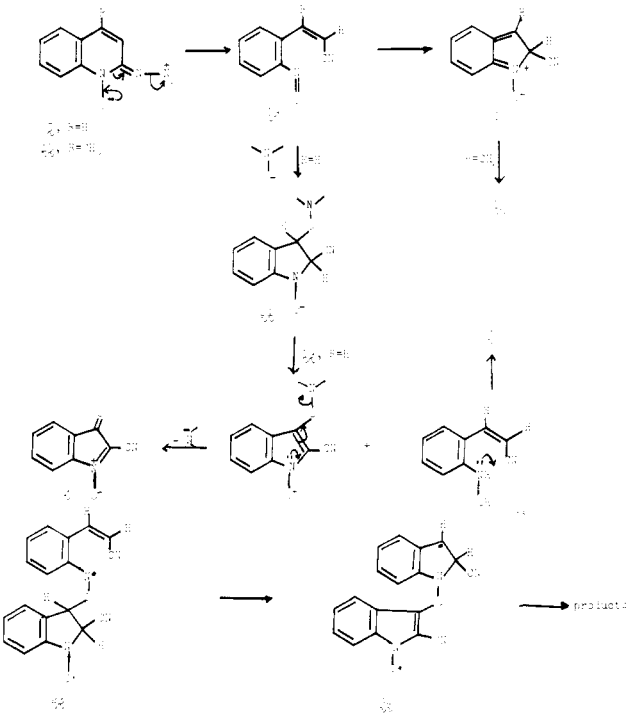
Scheme III



Scheme IV



trans-*o*-nitrocinnamonitrile (**13**)[8] with excess triethyl phosphite in mesitylene at 160 °C for 4 h gave 2-cyanoindole (**14**) in 69% yield, whose physical properties were identical with those reported in the literature.[9] Dimerization of **14** according to the procedure of Witkop and Patrick[10] for the conversion of 2-methylindole to 2,2′-dimethyl-3,3′-bis[indole] gave **10** in 21% yield together with much black intractable material. The infrared spectrum of **10** exhibited strong absorptions at 3300 (indole NH) and 2230 cm^{-1} (C≡N). The ultraviolet spectrum in 95% ethanol also supported the proposed structure with absorptions at 278 nm (ε 12 000) and 262 nm (ε 14 000). In the mass spectrum of **10** a molecular ion was observed at *m/e* 282 with a major fragment at *m/e* 141. The absence of significant fragmentation (less than 5% of base peak) between *m/e* 282 and 141 speaks for the symmetry of the molecule.

Thermolysis of 2-azidoquinoline 1-oxide (**5**) in methanol at 85 °C for 1 h gave **7** (32%), **9** (23%) and **10** (27%).

It was predicted that if a substituent were present at C-4 of **5**, it would block the formation of cyanoisatogens and bis[indoles] and lead to the formation of 1-hydroxyindoles. A study of the preparation and thermolysis of 2-azido-4-methylquinoline 1-oxide (**15**) was undertaken. Oxidation of 2-chloro-4-methylquinoline (**16**)[11] with monopermaleic acid in chloroform gave the corresponding *N*-oxide **17** in 77% yield. Treatment of **17** with sodium azide in aqueous acetone containing 1 equiv of concentrated hydrochloric acid gave 2-azido-4-methylquinoline 1-oxide (**15**) in 50% yield. When **15** was heated in toluene at 100 °C for 15 min it gave 2-cyano-1-hydroxy-3-methylindole (**18**) in 44% yield (Scheme III). The structure of **18** followed from its spectral properties: the infrared spectrum of **18** exhibited a very broad absorption centered at 2950 cm^{-1} with a strong absorption at 2220 cm^{-1} (C≡N). The NMR spectrum of **18** consisted of a broad singlet at δ 7.90 which underwent exchange with D_2O, a four-proton multiplet at δ 7.62, and a three-proton singlet at δ 2.67. The mass spectrum exhibited a molecular ion at *m/e* 172 with principal fragments at *m/e* 155 ($M^{+\cdot}$ – OH) and *m/e* 128 ($M^{+\cdot}$ – OH – HCN).

One possible explanation for the complex results observed in the thermolysis of 2-azidoquinoline 1-oxide (**5**) is a disproportionation of the initially formed 2-cyano-1-hydroxyindole (**6**) to 2-cyanoisatogen (**9**) and 2,2′-dicyano-3,3′-bis[indole] (**10**). It is well documented that 1-hydroxy-2-phenylindole undergoes a thermal disproportionation in *p*-cymene at 180 °C to give 2,2′-diphenyl-3,3′-bis[indole].[12] However, 2-phenylisatogen was not detected when 1-hydroxy-2-phenylindole was heated in toluene at 100 °C for 2 h (conditions slightly more drastic than those used in the decomposition of the azide). We found that it was recovered unchanged. It is also difficult to envision the transformation of **6** into **7**, although formation of 2-aminoquinoline 1-oxide (**7**) might arise via hydrogen abstraction by a 1-oxo-2-quinolylnitrene. We have never observed a nitrene pathway in any of the reactions of the corresponding azidopyridine 1-oxides.[2] Indeed, the above reaction conditions are much milder than those usually required for the unimolecular N–N bond cleavage in an aryl azide to yield an arylnitrene.

The other explanation of the results, which we favor, is depicted in Scheme IV. Concerted elimination of nitrogen and ring opening of the azides (**5** and **15**) would lead to *cis*-*o*-nitrosocinnamonitrile (**19**). Since ring closure of **19** to give 1-hydroxyindoles leads to destruction of aromaticity of the benzene ring, nucleophilic addition of an oxygen atom (from starting *N*-oxide or ring-contracted product) to the α,β-unsaturated nitrile **19** could compete favorably with intramolecular ring contraction. When **19** is substituted with an alkyl group on the β-carbon, Michael-type addition reactions are suppressed, and a normal ring contraction to **18** occurs. The dihydro intermediate **21** could then serve as a reducing agent for **19** to give **7** via intramolecular cyclization of the initially formed hydroxylamine **22**. This oxidation of **21** followed by elimination leads to 2-cyanoisatogen (**9**) and a deoxygenated species which could then be oxidized to **10**. Alternatively, a radical process involving 2 mol of nitroso derivative could lead to a diradical such as **23** and thence to **24** and to the observed products. There is insufficient data at present to warrant any further speculation. A nitrene is not invoked to explain the formation of 2-aminoquinoline 1-oxide. Clearly, as predicted, blocking C_4 of the azidoquinoline 1-oxide suppresses the intramolecular pathway and permits the

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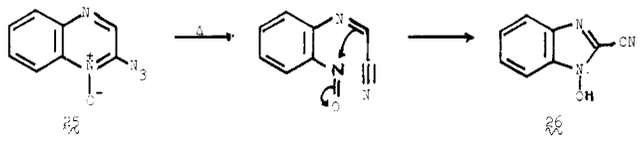
normal ring contraction to occur.

On that basis, it was expected that 2-azidoquinoxaline 1-oxide (**25**) would undergo straightforward ring contraction to 2-cyano-1-hydroxybenzimidazole (**26**), and this was



indeed found to be the case. Azide **25** was prepared from 2-chloroquinoxaline 1-oxide[13] in aqueous acetone at room temperature. Attempted recrystallization gave **26**. The structure of **26** was confirmed by its spectral properties and by its unambiguous synthesis from (2-nitroanilino)-acetonitrile.[14] It formed an *O*-tosylate readily. The reaction has recently been extended to the ring contraction of the other 2-azidoquinoxaline 1-oxides,[15] and it was confirmed that **25** cannot be purified without decomposition.

Experimental Section[16]

2-Azidoquinoline 1-Oxide (5). A solution of 2-chloroquinoline 1-oxide[17] (1.66 g, 0.0093 mol), sodium azide (2.00 g, 0.031 mol), and concentrated hydrochloric acid (1 mL) in water (50 mL) and acetone (100 mL) was stirred at room temperature for 72 h. The solid which precipitated was collected and chromatographed on basic alumina (150 g, 60–200 mesh). Elution with chloroform gave **5** as yellow needles: 1.01 g (58%); mp 103.5–104.5 °C dec; IR (KBr) 3030–3000, 2160, 2140 (N_3), 1265 cm^{-1} (N^+–O^-); NMR ($CDCl_3$) δ 8.65 (dd, 1 H, $J_{7,8}$ = 9 Hz, $J_{6,8}$ = 2 Hz, H_8), 8.00–7.50 (m, 4 H, H_4, H_5, H_6, and H_7), 6.96 (d, 1 H, $J_{3,4}$ = 8 Hz, H_3); mass spectrum (10 eV), *m/e* 186 ($M^{+\cdot}$), 158 ($M^{+\cdot} - N_2$). Anal. Calcd for $C_9H_6N_4O$: C, 58.07; H, 3.22. Found: C, 57.94; H, 3.45.

Thermolysis of 5 in Toluene. A degassed solution of 2-azidoquinoline 1-oxide (620 mg, 0.0033 mol) in toluene (20 mL) was heated in a sealed tube at 100 °C for 15 min. Cooling the solution and collecting the precipitate afforded 2-aminoquinoline 1-oxide (**7**): 112 mg (21%); mp 151–153 °C (lit.[4] mp 155 °C); IR (KBr) 3400, 3300 (NH_2), 1268 cm^{-1} (N^+–O^-); mass spectrum (70 eV), *m/e* 160 ($M^{+\cdot}$), 144 ($M^{+\cdot} - O$). The filtrate was evaporated under vacuum to give a red oil (351 mg) which was chromatographed on silica gel (50 g, 60–80 mesh). Elution with benzene gave 2-cyanoisatogen (**9**): (115 mg (22%); mp 198–200 °C dec; IR (KBr) 2230 (C≡N), 1710 (C=O), 1515 cm^{-1} (N^+–O^-); NMR ($CDCl_3$) δ 7.60–7.20 (m, 4 H); mass spectrum (70 eV), *m/e* 172 ($M^{+\cdot}$), 156 ($M^{+\cdot} - O$); high-resolution mass spectrum, calcd for $C_9H_4N_2O_2$ *m/e* 172.0273, found *m/e* 172.0243. Elution with chloroform gave 2,2′-dicyano-3,3′-bis[indole]: 203 mg (21%); mp 184 °C dec; IR (KBr) 3260 (NH), 2220 cm^{-1} (C≡N); NMR ($CDCl_3$) δ 9.80 (br s, 1 H, NH), 7.60–7.10 (m, 8 H, phenyl H); UV λ_{max} (EtOH) 278 nm (ϵ 12 000), 262 (14 400); mass spectrum (70 eV), *m/e* 282 ($M^{+\cdot}$), 141 (base peak). Anal. Calcd for $C_{18}H_{10}N_4$: C, 76.59; H, 3.58. Found: C, 76.43; H, 3.85.

In a similar experiment heating **5** in methanol in a sealed tube at 85 °C for 3 h gave **7** (32%), **9** (23%), and **10** (27%).

2-Chloro-4-methylquinoline 1-Oxide (17). A solution of 2-chloro-4-methylquinoline[11] (2.00 g, 0.013 mol) in chloroform (50 mL) was added to a solution of maleic anhydride (1.40 g, 0.014 mol) and 90% aqueous hydrogen peroxide (1 mL) in chloroform (100 mL) at 5 °C. The solution was kept at 0 °C for 4 days, and then saturated aqueous potassium carbonate solution was added. The organic layer was separated, dried ($CaCl_2$), and evaporated under vacuum to give 2-chloro-4-methylquinoline 1-oxide: 1.66 g (77%); mp 146–148 °C dec; IR (KBr) 1245 cm^{-1} (N^+–O^-); NMR ($CDCl_3$) δ 8.84 (dd, 1 H, $J_{7,8}$ = 7 Hz, $J_{6,8}$ = 3 Hz, H_8), 8.10–7.50 (m, 3 H, H_5, H_6, and H_7), 7.28 (s, 1 H, H_3), 2.61 (s, 3 H, 4-CH_3); mass spectrum (70 eV), *m/e* 193 ($M^{+\cdot}$, ^{35}Cl), 177 ($M^{+\cdot} - O$). Anal. Calcd for $C_{10}H_8ClNO$: C, 62.02; H, 4.16. Found C, 62.20; H, 4.25.

2-Azido-4-methylquinoline 1-Oxide (15). A solution of 2-chloro-4-methylquinoline 1-oxide (1.60 g, 0.0083 mol), sodium azide (2.00 g, 0.031 mol), and concentrated HCl (1 mL) in water (50 mL) and acetone (100 mL) was stirred at room temperature for 4 days. Extraction of the solution with $CHCl_3$ gave 2-azido-4-methylquinoline 1-oxide: 840 mg (50%); mp 101–103 °C dec; IR (KBr) 2100 (N_3), 1255 cm^{-1} (N^+–O^-); NMR ($CDCl_3$) δ 8.52 (dd, 1 H, $J_{7,8}$ = 4.7 Hz, $J_{6,8}$ = 1 Hz, H_8), 7.86–7.22 (m, 3 H, H_5, H_6, and H_7), 6.67 (s, 1 H, H_3), 2.53 (s, 3 H, 4-CH_3); mass spectrum (10 eV), 200 ($M^{+\cdot}$), 172 ($M^{+\cdot} - N_2$), 159 ($M^{+\cdot} - N_3$). Anal. Calcd for $C_{10}H_8N_4O$: C, 56.99; H, 4.00. Found C, 56.77; H, 4.19.

2-Cyano-1-hydroxy-3-methylindole (18). A degassed solution of 2-azido-4-methylquinoline 1-oxide (650 mg, 0.0033 mol) in toluene (21 mL) was heated in a sealed tube at 100 °C for 15 min. Evaporation of the solvent gave a residue (400 mg) which was chromatographed on silica gel (50 g, 60–80 mesh). Elution with benzene gave 2-cyano-1-hydroxy-3-methylindole: 250 mg (44%); mp 129–130 °C (cyclohexane); IR (KBr) 3250 (NOH), 2900 (bonded NOH), 2230 cm^{-1} (C≡N); NMR ($CDCl_3$) δ 7.87 (br s, 1 H, NOH), 7.63 (m, 4 H, phenyl protons), 2.63 (s, 3 H, 3-CH_3); mass spectrum (70 eV), *m/e* 172 ($M^{+\cdot}$), 157 ($M^{+\cdot} - CH_3$), 156 ($M^{+\cdot} - O$), 155 ($M^{+\cdot} - OH$). Anal. Calcd for $C_{10}H_8N_2O$: C, 69.77; H, 4.71. Found: C, 69.60; H, 4.82.

2-Cyanoisatogen. A. Triphenylphosphonium α-Cyano-*o*-nitrophenacylide (11). A solution of triphenylphosphine (15.0 g, 0.06 mol) and chloroacetonitrile (4.56 g, 0.06 mol) in dry benzene (150 mL) was boiled under reflux for 12 h. When the mixture cooled, (cyanomethyl)triphenylphosphonium chloride precipitated as colorless needles: 18.25 g (90%); mp 243 °C (lit.[5] mp 246 °C). To a vigorously stirred solution of this chloride (18.0 g, 0.053 mol) and triethylamine (11.0 g, 0.108 mol) in dry benzene (200 mL) was added a solution of *o*-nitrobenzoyl chloride (10.0 g, 0.053 mol) in benzene (100 mL) dropwise over a period of 1 h. The solution was then boiled under reflux for 6 h. Evaporation of the solvent gave a residue which was recrystallized from methanol to give triphenylphosphonium α-cyano-*o*-nitrophenacylide: 21.0 g (87%); mp 127–128 °C dec; IR (KBr) 2180 (C≡N), 1526 (asym NO_2), 1350 (sym NO_2), 1110 cm^{-1} (P^+R_3). Anal. Calcd for $C_{27}H_{19}N_2O_3P$: C, 72.00; H, 4.23; N, 6.25. Found: C, 71.78; H, 4.37; N, 6,08.

B. (*o*-Nitrophenyl)propiolonitrile (12). In a one-necked, round-bottomed flask fitted for vacuum distillation was pyrolyzed triphenylphosphonium α-cyano-*o*-nitrophenacylide (1.50 g, 0.0033 mol) at 265 °C (5 mm) over a period of 1 h. As it formed, (*o*-nitrophenyl)propiolonitrile was removed by distillation and trapped in a cold receiver (100 mg, 18%) as a viscous yellow oil: IR (film) 2275 (C≡C or C≡N), 1529 (asym NO_2), 1342 (sym NO_2), 785 cm^{-1}. Since this material decomposed rapidly on being allowed to stand, it was used in the next step without further purification.

C. 2-Cyanoisatogen (9). A benzene solution of (*o*-nitrophenyl)propiolonitrile (88 mg, 0.51 mol) in a Pyrex vessel was irradiated at 3000 Å in a Rayonet photochemical reactor for 24 h. Evaporation of the solvent in vacuo gave 2-cyanoisatogen: 42 mg (48%); mp 199–201 °C dec; IR (KBr) 2230 (C≡N), 1710 (C=O), 1515 (N^+—O^-), 1396, 775 cm^{-1}; identical with the compound obtained from the azide.

2-Cyanoindole (14). A degassed solution of *trans*-*o*-nitrocinnamonitrile[8] (425 mg, 0.0025 mol) and triethyl phosphite (743 mg, 0.0045 mol) in mesitylene (15 mL) was heated in a Fischer-Porter tube at 170 °C for 3.5 h. After the mixture cooled, the solvent was evaporated in vacuo, and the residue was dissolved in ether, washed with water, and dried ($MgSO_4$). After removal of the ether in vacuo, the residue was chromatographed on silica gel (50 g, 60–80 mesh, 2 × 20 cm). Elution with benzene–hexane (4:1 v/v) gave 2-cyanoindole: 239 mg (69%); mp 100–101 °C (lit.[9] mp 101 °C) (from hexane); IR (KBr) 3280 (NH), 3110, 2220 cm^{-1} (C≡N); NMR ($CDCl_3$) δ 9.70 (br s, 1 H, NH, exchanges with D_2O), 7.50 (m, 4 H, phenyl protons), 6.67 (s, 1 H, H_3); mass spectrum (70 eV), *m/e* (relative intensity) 143 (11), 142 (100), 141 (4).

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(16) Melting points are uncorrected. NMR spectra were recorded on a Varian Associates HA-100 or Hitachi Perkin-Elmer R-20B spectrometer using tetramethylsilane as internal standard; mass spectra were measured on a CEC 21-104 spectrometer.

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2,2′-Dicyano-3,3′-bis[indole] (10). A solution of 2-cyanoindole (825 mg, 0.0023 mol) and finely cut potassium (86 mg, 0.0022 mol) in xylene (10 mL) was heated at 140 °C in an oil bath for 6 h. The solution was cooled and iodine (280 mg, 0.0011 mol) in xylene (15 mL) was added. After being stirred for 10 h, the solution was filtered and the filtrate evaporated in vacuo to give a residue which was chromatographed on neutral alumina (Camag, Brockmann activity 1, 50 g, 2 × 20 cm). Elution with benzene gave 2-cyano-3-iodoindole: 18 mg (2.6%); mp 170 °C dec; IR (KBr) 3350 (NH), 2230 cm^{-1} (C≡N); mass spectrum (70 eV), *m/e* (relative intensity), 268 (M^{+}·, 71), 141 (M^{+}· − I, 100), 115 (27), 114 (48), 76 (27), 52 (21). Elution with chloroform gave 2,2′-dicyano-3,3′-bis[indole]: 57 mg (22%); mp 184 °C dec; identical with the material obtained from the thermolysis of 2-azidoquinoline 1-oxide (**5**).

2-Azidoquinoxaline 1-Oxide and Its Decomposition to 26. A solution of 2-chloroquinoxaline 1-oxide (0.5 g, 0.0028 mol), NaN_3 (0.5 g, 0.008 mol) and concentrated HCl (0.5 mL) in acetone (35 mL) and water (35 mL) was stirred at room temperature for 72 h. Extraction with $CHCl_3$ gave an oil (0.5 g) which was chromatographed on basic alumina (50 g, 60–200 mesh, 4 × 10 cm). Elution with CH_2Cl_2 gave 2-chloroquinoxaline 1-oxide: 386 mg (77%); mp 114–116 °C. Elution with $CHCl_3$ gave 2-azidoquinoxaline 1-oxide (**25**): 85 mg (68% based on chloride consumed); mp 101–104 °C dec; IR (KBr) 2170, 2130 (N_3), 1260 cm^{-1} (N^{+}–O^{-}). Attempts to recrystallize this compound led to its decomposition and the formation of 2-cyano-1-hydroxybenzimidazole (**26**): 73 mg (87%); mp 236–238 °C dec (lit.[14] mp 236 °C); identical (IR, NMR, mass spectrum) with an authentic sample.[14]

2-Cyano-1-(*p*-toluenesulfonyloxy)benzimidazole. A solution of **25** (1.10 g) and *p*-toluenesulfonyl chloride (1.90 g) in CH_2Cl_2 (75 mL) and pyridine (1 mL) was boiled under reflux for 5 h and then kept at room temperature overnight. The solution was washed with 10% aqueous K_2CO_3 and the organic layer separated, dried ($MgSO_4$), and evaporated in vacuo to give the tosylate: 1.40 g (65%); mp 112–114 °C (EtOH); IR (KBr) 2250 (C≡N), 1400, 1182, 1090 cm^{-1}; NMR ($CDCl_3$) δ 7.90 (d, 2 H, J_o = 8 Hz, toluene protons), 7.50 (m, 4 H, benzimidazole protons), 7.48 (d, 2 H, J_o = 8 Hz, toluene protons). Anal. Calcd for $C_{15}H_{11}N_3O_3S$: C, 57.50; H, 3.52; N, 13.42. Found: C, 57.45; H, 3.67; N, 13.63.

Attempted Thermal Disproportionation of 1-Hydroxy-2-phenylindole at 100 °C. A solution of 1-hydroxy-2-phenylindole[18] (0.5 g) in toluene (21 mL) was heated at 100 °C for 2 h. Evaporation of the solvent gave unchanged starting material: 485 mg (97%); mp 170–172 °C.

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Registry No. **5**, 51796-60-2; **7**, 30958-68-0; **8**, 2423-68-9; **9**, 51796-61-3; **10**, 51796-62-4; **11**, 75548-90-2; **12**, 51796-64-6; **13**, 51991-49-2; **14**, 36193-65-4; **15**, 51796-68-0; **16**, 634-47-9; **17**, 10286-18-7; **18**, 51796-66-8; **25**, 51796-69-1; **26**, 40159-90-8; (cyanomethyl)-triphenylphosphonium chloride, 4336-70-3; triethyl phosphite, 554-70-1; mesitylene, 25551-13-7; 2-chloroquinoxaline 1-oxide, 5227-57-6; 2-cyano-1-(*p*-toluenesulfonyloxy)benzimidazole, 75558-42-8; 1-hydroxy-2-phenylindole, 1859-39-8.

Stereospecific Synthesis of N-Substituted *cis*-2-Aryl-3-alkylaziridines

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A convenient stereospecific synthesis of N-substituted *cis*-2-aryl-3-alkylaziridines is reported, by reaction of *N*-alkyl or *N*-aryl α,α-dichloroalkyl aryl ketimines with lithium aluminum hydride in ethereal medium. The mechanism involves the addition of hydride at the carbon–nitrogen double bond followed by intramolecular chloride displacement and loss of chloride anion from the intermediate α-chloroaziridine to generate an azirinium chloride, which is stereospecifically attacked by hydride to afford the title compounds. The formation of some side reactions in the case of *N*-aryl derivatives is discussed.

Introduction

Several methods have been described in the literature for the stereospecific synthesis of *cis*-aziridines.[2] Practically all of them suffer from the use of difficultly accessible starting materials or are less convenient because of the formation of various side products, which make the purification of the desired products difficult and laborious. N-Substituted *cis*-aziridines have been prepared from *threo*-β-amino alcohols by means of the Wenker procedure, i.e., conversion into the sulfate ester and base-induced intramolecular nucleophilic substitution,[3,4] or by means of triphenylphosphine dihalide and base treatment.[5–7] An analogous method involved the transformation of *erythro*-β-amino alcohols into *threo*-β-chloro amines (using PCl_5, $SOCl_2$, ...) with subsequent base-induced ring closure.[8,9] In one single case, (dimethylamino)-(*p*-tolyloxo)sulfonium ethylide was reported to condense stereospecifically with benzylideneaniline to produce the *cis*-aziridine.[10] A more general stereospecific synthesis of *cis*-aziridines entailed the reaction of *threo*-β-iodoalkyl azides with aryl- and alkyldichloroboranes to give the corresponding β-iodo

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