

The Synthesis of Benzo[*c*]cinnoline 5,6-Dioxides and Related Compounds

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The preparation of a variety of benzo[*c*]cinnolines as well as benzo[*c*]cinnoline monoxides and dioxides by reduction of the corresponding 2,2'-dinitrobiphenyls with hydrogen and Raney nickel of low activity is described. The detailed procedures developed produce superior yields of benzo[*c*]cinnoline monoxides and dioxides. The structure of some intensely-colored red-violet amino, alkylamino, and hydroxybenzo[*c*]cinnoline monoxides and dioxides is discussed and these are compared with the essentially colorless alkoxy and acetylamino derivatives. The long wave length band in the U.V. spectrum of the colored compounds is compared.

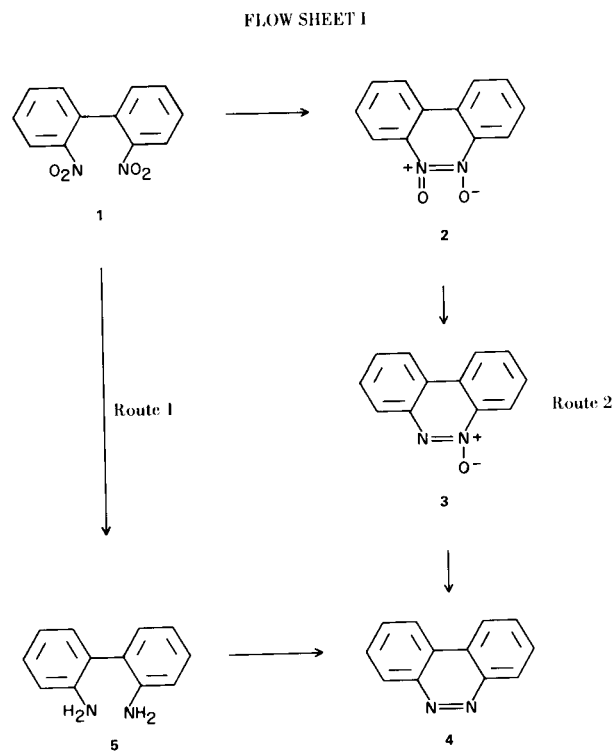
Benzo[*c*]cinnolines (4) normally are prepared by reductive cyclization of 2,2'-dinitrobiphenyls (1). E. Tauber (3) discovered this reductive cyclization and found that the dioxide (2) and the monoxide (3) were intermediates in this reaction. Several reduction methods of 2,2'-dinitrobiphenyls are reported in a review by Buntrock and Taylor (4). Benzo[*c*]cinnolines can be prepared also by oxidation of the corresponding 2,2'-diaminobiphenyls (5) but the reported yields are not as good as in the reduction of the 2,2'-dinitrobiphenyls.

During a search of the literature concerning possible reduction methods it was observed that there have been no comprehensive investigations with Raney nickel in this field. Moore and Furst (6) first reported investigations with the Raney nickel-hydrazine reducing system, mentioning the importance of type and activity of the Raney nickel. Our attempts to adapt this method in a series of substituted 2,2'-dinitrobiphenyls were unsuccessful. Using an old sample of Raney nickel W-1, Bavin (7) obtained benzo[*c*]cinnoline (4) in very good yield.

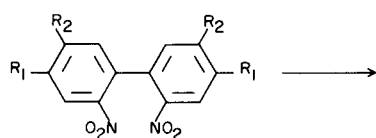
The preparation of benzo[*c*]cinnoline 5,6-dioxide (2) by oxidation of the corresponding monoxide (3) was recently reported in poor yield by Suzuki, *et al.*, (8). These authors also reported the synthesis of pyridazine dioxide (9) and cinnoline dioxide (8).

In a previous communication from this laboratory (10) a general method for the preparation of benzo[*c*]cinnoline 5,6-dioxides (12-17) by catalytic reduction of 2,2'-dinitrobiphenyls (6-11) was reported. As catalyst, aged samples of Raney nickel W-6 or W-7 (11) were used in ethanolic solution containing a small amount of alkali. Good results were obtained when the catalyst was stored (aged) at 25° under absolute ethanol for 6-12 weeks. The

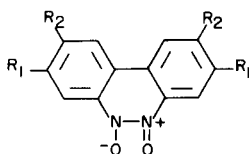
amount of hydrogen used was almost equivalent to the theoretical amount for this step of the reaction. The crude material contained a little monoxide which could be removed normally by recrystallization (12,13,15,17) and column chromatography (14,16).



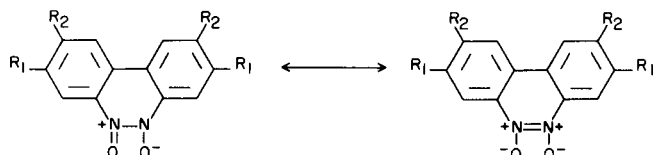
## FLOW SHEET II



	6	7	8	9	10	11
R <sub>1</sub>	H	CH <sub>3</sub>	H	OCH <sub>3</sub>	H	COOCH <sub>3</sub>
R <sub>2</sub>	H	H	CH <sub>3</sub>	H	OCH <sub>3</sub>	H



	12	13	14	15	16	17
R <sub>1</sub>	H	CH <sub>3</sub>	H	OCH <sub>3</sub>	H	COOC <sub>2</sub> H <sub>5</sub>
R <sub>2</sub>	H	H	CH <sub>3</sub>	H	OCH <sub>3</sub>	H



Raney nickel W-6 was found to be a better catalyst when the starting material contained no substituent (6) or moderate electron-donating substituents such as methyl groups (7,8). The more active and alkali-containing

Raney nickel W-7 was used in case of the biphenyls (9,10) with methoxy substituents as electron-donating groups.

The structure of benzo[c]cinnoline 5,6-dioxide (2) has been discussed by Ross, *et al.*, (12), by Ross and Kuntz (13) and Suzuki, *et al.*, (8). Suzuki, *et al.*, (8) suggested the charge-separated structures (12-17) because of their inertness towards phosphorus trichloride, the formation of the dioxide (2) from the monoxide (3) by *N*-oxidation, and the high melting point of the dioxide when compared with the monoxide.

Furthermore, reduction of 2,2'-dinitrobiphenyls (7-10) led to benzo[c]cinnoline monoxides (23-24) or benzo[c]cinnolines (19,21), depending upon the activity of the catalyst used, the amount of hydrogen absorbed and the substituents present. Preparation of the benzo[c]cinnolines (13,21) was carried out readily with the less active Raney nickel W-6. In the reaction solution no amine was observed by TLC. In contrast, the reduction of 2,2'-dinitrodimeoxybiphenyls were easily reduced to the monoxide stage but further reduction to benzo[c]cinnolines was difficult, especially when the methoxyl groups are in the 2,9-positions. This was readily shown by a measure of the polarographic half-wave potentials.

Reduction of 2,2'-dinitro-4,4'-dicarbomethoxybiphenyl (11) gave the dioxide in good yield. The crude solid material contained a small amount of the monoxide (18), however, the mother liquor contained some 2,2'-diamino-4,4'-dicarbomethoxybiphenyl, as indicated by TLC.

This prompted us to prepare the 3,8-dicarbomethoxybenzo[c]cinnoline (27) and 3,8-dicarbomethoxybenzo[c]cinnoline monoxide (28) by oxidation of the 2,2'-diamino-4,4'-dicarbomethoxybiphenyl (26) prepared by reduction of the 2,2'-dinitro-4,4'-dicarbomethoxybiphenyl (11) with freshly prepared Raney nickel W-2 (11).

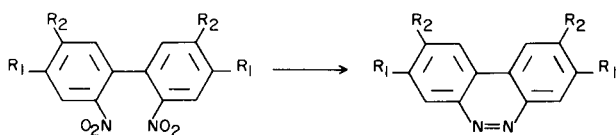
Oxidation of 2,2'-diamino-4,4'-dicarbomethoxybiphenyl (26) with 50% hydrogen peroxide in acetic acid solution at room temperature gave 3,8-dicarbomethoxybenzo[c]cinnoline (27) in very good yield. The corresponding monoxide (28) was obtained at 80°.

Moore and Furst (6) reported that the reduction of 2,2'-dinitrobiphenyl (1) to 2,2'-diaminobiphenyl (5) proceeds by two mechanisms. Our results with freshly prepared Raney nickel W-2 catalyst indicates that route 2 (Flow Sheet I) was always followed and this was established by TLC during the reaction, since 2, 3, and 4 were always detected.

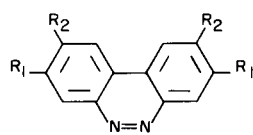
The polarographic reduction of benzo[c]cinnolines and the corresponding mono- and dioxides were determined and the values of the half-wave potentials are summarized in Table I.

An examination of the values of the half-wave potentials indicates that the benzo[c]cinnoline dioxides are more

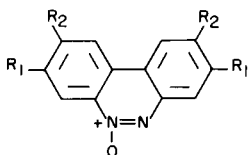
## FLOW SHEET III



	7	8	9	10
R <sub>1</sub>	CH <sub>3</sub>	H	OCH <sub>3</sub>	H
R <sub>2</sub>	H	CH <sub>3</sub>	H	OCH <sub>3</sub>



	19	21
R <sub>1</sub>	CH <sub>3</sub>	H
R <sub>2</sub>	H	CH <sub>3</sub>



	23	24
R <sub>1</sub>	OCH <sub>3</sub>	H
R <sub>2</sub>	H	OCH <sub>3</sub>

TABLE I  
Polarographic Half-wave Potentials  $-e_{1/2}$

	Azo Compound	Monoxide	Dioxide (14)
Benzo[c]cinnoline	0.82 (12)	1.02 (12)	0.76 1.04 (12)
3,8-Dimethyl-	0.83	1.00	0.76 1.04
2,9-Dimethyl-	0.93	0.99	0.79 1.11
3,8-Dimethoxy-	0.53 0.76	1.00	0.75 1.02
2,9-Dimethoxy-	0.90	1.16	0.83 1.20
3,8-Dicarbomethoxy-	0.70	0.85	
3,8-Dicarbomethoxy-		0.87	0.60 0.87
3,8-Diamino-			0.76 1.06
3,8-Bis(dimethylamino)-	0.90	1.09	
3,8-Bis(diethylamino)-		1.10	0.99
3,8-Dihydroxy-	0.80	0.69 1.21	0.55 0.89 1.24

readily reduced than are the benzo[c]cinnolines and these in turn are more readily reduced than the benzo[c]cinnoline monoxides confirming the observations of Suzuki, *et al.*, in the pyridazine (9) and cinnoline series (8) as well as the observation of Ross, *et al.*, with benzo[c]cinnoline and its oxides (12). The first half-wave potential in the reduction of the dioxides correspond to the reduction of one oxygen function. The second half-wave potential of

the dioxides corresponds to the reduction of the second oxygen of the dioxides. These latter values correspond to the reduction of the monoxides. As expected, the half-wave potentials were shifted to higher potentials when the electron-donating methoxyl groups were in the *p*-position and shifted to lower potentials when the electron withdrawing carbalkoxy groups were in the *m*-position to the ring nitrogen atoms.

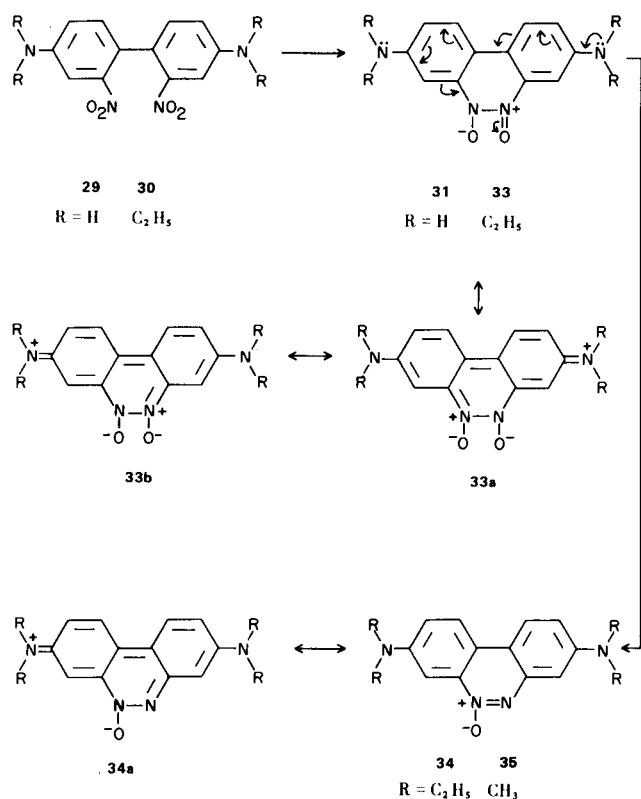
During further studies of the reduction of 2,2'-dinitro-4,4'-diaminobiphenyl (29) and 2,2'-dinitro-4,4'-bis(diethylamino)biphenyl (30) red-violet compounds were obtained which were identified as the dioxides (31,33), respectively. Acetylation of compound 31 gave the yellow diacetyl product (32).

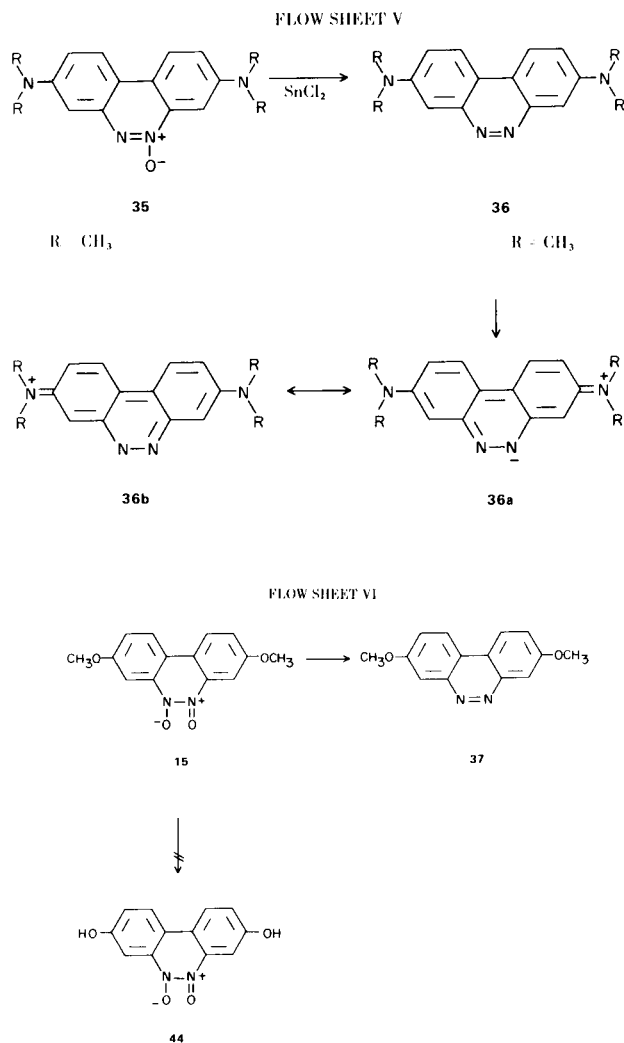
The electronic absorption data in ethanol at 496  $m\mu$  for compound 31 and 533  $m\mu$  for compound 33 prompted us to formulate the identical mesomeric structures 33a and 33b in addition to the structures 12-17.

On further reduction the deep-colored monoxide (34) was obtained. The monoxide (35) was reported by direct reduction with sodium sulfide (15). The electronic absorption data taken in ethanol shows a blue shift to 519  $m\mu$  for 34 and 35 when compared with the dioxide (33) because it is not possible to formulate more than one reasonable quinoid form (34a).

Complete deoxygenation of 35 by reduction with stannous chloride (15) gave compound 36 which shows an electronic absorption at 499  $m\mu$  in ethanol. In addition to formula 36 two mesomeric forms 36a and 36b can be formulated but as expected these do not make a significant contribution to the hybrid. The long wavelength ultraviolet absorption bands of all compounds reported above show an intense blue shift indicating a  $\pi-\pi^*$  transition when the electronic absorption data were taken in cyclohexane solution (16). These results are recorded in the

## FLOW SHEET IV

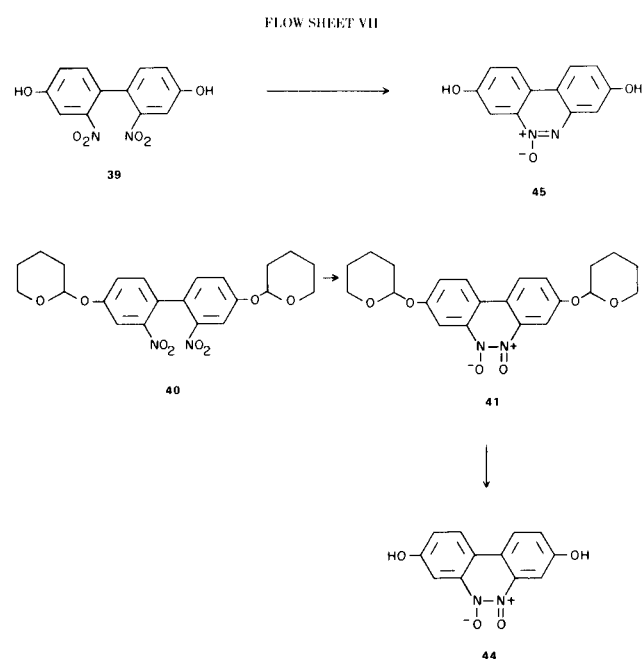




#### experimental part.

Attempts to hydrolyze 3,8-dimethoxybenzo[*c*]cinnoline 5,6-dioxide (**15**) with 50% hydriodic acid to 3,8-dihydroxybenzo[*c*]cinnoline 5,6-dioxide (**44**) failed and instead 3,8-dimethoxybenzo[*c*]cinnoline (**37**) was obtained. The reduction of 2,2'-dinitro-4,4'-dihydroxybiphenyl (**39**) prepared by the Ullmann reaction of 1-acetoxy-4-iodo-3-nitrobenzene (**26**) and hydrolysis gave only the monoxide (**45**). The homogenous reaction was carried out in ethanol-water at pH 9. However, the preparation of 3,8-dihydroxybenzo[*c*]cinnoline 5,6-dioxide (**44**) was successful after protecting the phenolic hydroxyl groups with tetrahydropyranyl groups to give the biphenyl (**40**). After reduction in the usual manner the dioxide (**41**) and the monoxide (**42**) were separated by preparative TLC and the hydrolysis of both compounds was smoothly carried out in ethanol containing a little hydrochloric acid.

In the same way as described for compounds **44** and **45**, the 3,8-dihydroxybenzo[*c*]cinnoline (**46**) was prepared.



On addition of alkali the dioxide (**44**) and monoxide (**45**) turn red-violet in color. Compound **46** became red when alkali was added.

Ultraviolet absorption data measured in 0.1 *N* sodium hydroxide solution show a long wavelength band at 529  $m\mu$  for the dioxide (**44**) and 521  $m\mu$  for the monoxide (**45**). The blue shift of the anion (**46a-b**) of the long wavelengths band at 502  $m\mu$  is also consistent with the results obtained in the 3,8-bisdialkylaminobenzo[*c*]cinnoline series. A long wavelength band at 490  $m\mu$  was also found for the 3,8-dihydroxybenzo[*c*]cinnoline cation (**46a-b**) in 0.1 *N* hydrochloric acid solution explained by the formulated mesomeric species **46c** and **46d** from which the latter accounts most for the long wave band given above.

Similar results were obtained for the 3,8-dimethoxybenzo[*c*]cinnoline (**37**). The ultraviolet spectrum taken in 0.1 *N* hydrochloric acid solution shows a long wave length band at 475  $m\mu$ .

$pK_a$  Investigations of 3,8-dihydroxybenzo[*c*]cinnoline 5,6-dioxide (**44**) and 3,8-dihydroxybenzo[*c*]cinnoline (**45**) by the spectroscopic method show no  $pK_a$  value in the acidic region as anticipated. The attempts to determine the  $pK_a$  data in the basic region failed because of overlapping  $pK_a$  values. 3,8-Dihydroxybenzo[*c*]cinnoline (**46**) shows a  $pK_a$  value at  $2.4 \pm 0.1$  and in the basic region only an approximate value of 8.5 was found because of the reasons mentioned above.

## EXPERIMENTAL

## General Remarks.

The Preparation of the dioxides was carried out with finely powdered starting material in ethanol and hydrogenated at 25° under atmospheric pressure. The W-6 and W-7 Raney nickel was aged at 25° for 6-12 weeks. After 12 weeks the quality of Raney nickel W-7 is doubtful. Raney nickel W-6 can be used without any difficulty after 12 weeks, especially when kept cold after this date. The reaction time for preparing the dioxide should not be shorter than 1 to 1.5 hours. At the end of the reaction benzo[c]cinnolines and monoxides were estimated by TLC. All compounds were found to be homogenous when examined by TLC in chloroform or chloroform-benzene on neutral or basic alumina. Exception: compounds **31** and **32** cannot be chromatographed because of insolubility. The hydroxybenzo[c]cinnolines were chromatographed on a silica using ethyl acetate as the eluent. Exception: compound **44** was not chromatographed because of insolubility. All compounds were dried at 90-100° *in vacuo* unless otherwise specified.

All melting points were determined on a Thomas Hoover melting point apparatus and are uncorrected. The infrared spectrum was determined with a Perkin-Elmer 337 spectrophotometer over the range 4000-400  $\text{cm}^{-1}$  in potassium bromide discs. The ultraviolet absorption data were taken with Cary Spectrophotometers Models 14R and 15. The polarographic half-wave potentials were determined with a Sargent Polarograph Model 16 in 40% ethanol; potassium chloride was used as the electrolyte and methylcellulose (0.005%) for maximum depression.

Benzo[c]cinnoline 5,6-Dioxide (**12**).

2,2'-Dinitrobiphenyl (2.4 g., 0.01 mole) (**6**) (**19**) in 200 ml. of absolute ethanol containing 4 ml. of 4% sodium hydroxide and Raney nickel W-6 was hydrogenated. After the uptake of 480 ml. of hydrogen the reaction mixture was filtered, the residue extracted with chloroform and ether was added to the warm solution, 1.05 g. (50%) of nearly colorless crystals, m.p. 249-250° dec. (lit. (3) 240° dec., 25% yield reported, (8) 231-233° dec., 71% yield reported by oxidation method (12,20), 234-236° dec.; infrared  $\text{cm}^{-1}$  (17), 1300-1500; 1308(m), 1357(m), 1362(w), 1390(s), 1420(m), 1465(m), 1475(s); U.V.  $\lambda$  max (95% ethanol), 214 ( $\epsilon$ , 14,350), 221 ( $\epsilon$ , 13,050), 240 ( $\epsilon$ , 30,500), sh 250 ( $\epsilon$ , 3,300), 258 ( $\epsilon$ , 37,850), sh 269 ( $\epsilon$ , 22,000), 291 ( $\epsilon$ , 13,150), 304 ( $\epsilon$ , 13,150), 345  $\mu$  ( $\epsilon$ , 1,150).

*Anal.* Calcd. for  $\text{C}_{12}\text{H}_8\text{N}_2\text{O}_2$ : C, 67.92; H, 3.80; N, 13.20. Found: C, 67.70; H, 3.63; N, 13.19.

3,8-Dimethylbenzo[c]cinnoline 5,6-Dioxide (**13**).

One g. (0.0037 mole) of 2,2'-dinitro-4,4'-dimethylbiphenyl (**7**) (**21**) in 100 ml. of absolute ethanol containing 2.0 ml. of 4% sodium hydroxide and Raney nickel W-6 was hydrogenated. After an uptake of 180 ml. of hydrogen the solid material was filtered, extracted with chloroform, evaporated and the chloroform extraction and evaporation repeated, yield, 0.45 g. (50%) of light yellow crystals, m.p. 265-266° dec.; U.V.  $\lambda$  max (95% ethanol), 211 ( $\epsilon$ , 7,200); 216 ( $\epsilon$ , 8,600), 224 ( $\epsilon$ , 7,900), sh 242 ( $\epsilon$ , 25,750), 256 ( $\epsilon$ , 40,000), 262 ( $\epsilon$ , 43,850), sh 275 ( $\epsilon$ , 32,650), sh 293 ( $\epsilon$ , 14,800), sh 307 ( $\epsilon$ , 10,250), 347 ( $\epsilon$ , 11,000), sh 385 ( $\epsilon$ , 2,700), sh 407  $\mu$  ( $\epsilon$ , 1,750).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_2$ : C, 69.99; H, 5.03; N, 11.66. Found: C, 69.75; H, 4.94; N, 11.48.

2,9-Dimethylbenzo[c]cinnoline 5,6-Dioxide (**14**).

Two g. (0.0075 mole) of 2,2'-dinitro-5,5'-dimethylbiphenyl

(**8**) (**22**) in 200 ml. of absolute ethanol containing 4 ml. of 4% sodium hydroxide and Raney nickel W-6 was hydrogenated until 360 ml. of hydrogen had been absorbed. The precipitate was filtered, dissolved in chloroform and evaporated to dryness to give 1.5 g. of crude material. The purification was carried out by column chromatography (3 x 40 cm. of aluminum oxide neutral Wöllm) with chloroform-benzene (1:1). When all the monoxide had been removed the product was eluted with chloroform. The fractions containing dioxide and monoxide were evaporated and chromatographed once more. The combined solutions after evaporation gave 1.2 g. (68%) of nearly colorless crystals, m.p. 260-261° dec., (lit. (23) 128° dec.); U.V.  $\lambda$  max (95% ethanol, sh 207 ( $\epsilon$ , 550), 211 ( $\epsilon$ , 4,200), 217 ( $\epsilon$ , 5,600), 223 ( $\epsilon$ , 3,100), 242 ( $\epsilon$ , 28,750), sh 251 ( $\epsilon$ , 32,100), 258 ( $\epsilon$ , 40,700), sh 267 ( $\epsilon$ , 24,400), 293 ( $\epsilon$ , 15,200), 304 ( $\epsilon$ , 16,100), 347 ( $\epsilon$ , 12,900), sh 379 ( $\epsilon$ , 2,800), sh 398  $\mu$  ( $\epsilon$ , 950).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_2$ : C, 69.99; H, 5.03; N, 11.66. Found: C, 69.88; H, 5.23; N, 11.71.

3,8-Dimethoxybenzo[c]cinnoline 5,6-Dioxide (**15**).

To 30 g. (0.01 mole) of 2,2'-dinitro-4,4'-dimethoxybiphenyl (**9**) (**24**) in 250 ml. of absolute ethanol was added 5 ml. of 4% sodium hydroxide and Raney nickel W-7. The mixture was hydrogenated. After an uptake of 480 ml. of hydrogen, the mixture was filtered with suction and the residue was extracted with chloroform. Ether was added to the warm yellow solution until incipient crystallization occurred. The mixture was allowed to stand overnight in the refrigerator; yield 1.5 g. (55%) m.p. 255-256° dec. Further purification in the same manner as described above gave 1.35 g. (50%) of yellow crystals, m.p. 256-257° dec.; U.V.  $\lambda$  max (95% ethanol), sh 224 ( $\epsilon$ , 86,000), 268 ( $\epsilon$ , 41,400), sh 282 ( $\epsilon$ , 21,900), 349 ( $\epsilon$ , 8,600), 410 ( $\epsilon$ , 3,200), 430  $\mu$  ( $\epsilon$ , 3,200).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_4$ : C, 61.76; H, 4.44; N, 10.29. Found: C, 61.69; H, 4.43; N, 9.98.

2,2'-Dinitro-5,5'-dimethoxybiphenyl (**10**).

Twenty-eight g. of stirred 4-nitro-3-iodoanisole (**18**) was heated in an oil bath to 140°, then 15 g. of copper powder (Matheson, Coleman and Bell) was added slowly at this temperature. The temperature was raised slowly to 170° and kept at this point for 1 hour. After cooling the reaction product was powdered and extracted with benzene. After evaporation to dryness some ether was added and filtered with suction. Recrystallization from ethanol gave 10 g. (80%) of nearly colorless crystals, m.p. 148-149°; U.V.  $\lambda$  max (95% ethanol), 213 ( $\epsilon$ , 22,900), sh 264 ( $\epsilon$ , 12,150), sh 296 ( $\epsilon$ , 560), 344  $\mu$  ( $\epsilon$ , 4,430).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_6$ : C, 55.27; H, 3.98; N, 9.21. Found: C, 55.23; H, 4.08; N, 9.37.

2,9-Dimethoxybenzo[c]cinnoline 5,6-Dioxide (**16**).

2,2'-Dinitro-5,5'-dimethoxybiphenyl (**10**) (1.5 g., 0.005 mole) in 150 ml. of absolute ethanol containing 3 ml. of 4% sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 240 ml. of hydrogen the reaction mixture was filtered with suction, the residue extracted with chloroform and evaporated to dryness. Final purification by column chromatography (2 x 40 cm) as reported for compound **14** gave 0.65 g. (50%) of nearly colorless crystals, m.p. 255° dec.; U.V.  $\lambda$  max (95% ethanol), 212 ( $\epsilon$ , 17,800), 268 ( $\epsilon$ , 42,000), 315 ( $\epsilon$ , 19,800), 358  $\mu$  ( $\epsilon$ , 13,700).

*Anal.* Calcd. for  $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_4$ : C, 61.76; H, 4.44; N, 10.29. Found: C, 61.77; H, 4.69; N, 9.94.

3,8-Dicarbomethoxybenzo[c]cinnoline 5,6-Dioxide (**17**).

2,2'-Dinitro-4,4'-dicarbomethoxybiphenyl (**11**) (**21**) (3.3 g.,

0.01 mole) in 600 ml. of absolute ethanol containing 2 ml. of 4% sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 500 ml. of hydrogen the mixture was filtered with suction, the residue extracted with chloroform and evaporated. Final purification by dissolving in chloroform and adding ether to the warm solution followed by cooling gave 2.1 g. (60%) of yellow crystals, m.p. >290 dec.; U.V.  $\lambda$  max (95% ethanol), 218 ( $\epsilon$ , 8,300), 240 ( $\epsilon$ , 23,100), sh 265 ( $\epsilon$ , 28,350), 276 ( $\epsilon$ , 39,400), 292 ( $\epsilon$ , 46,850), sh 314 ( $\epsilon$ , 13,700), 374  $m\mu$  ( $\epsilon$ , 8,000).

*Anal.* Calcd. for  $C_{18}H_{16}N_2O_6$ : C, 60.67; H, 4.53; N, 7.86. Found: C, 60.40; H, 4.35; N, 8.11.

From the mother liquor 200 mg. of the crude 3,8-dicarboethoxybenzo[c]cinnoline 5-oxide (18) was isolated to give after recrystallization from ethanol 100 mg. of light yellow needles, m.p. 204-206°; U.V.  $\lambda$  max (95% ethanol), sh 204 ( $\epsilon$ , 2,400), sh 218 ( $\epsilon$ , 18,700), 264 ( $\epsilon$ , 40,400), 272 ( $\epsilon$ , 40,100), sh 280 ( $\epsilon$ , 33,700), 294 ( $\epsilon$ , 31,100), 310 ( $\epsilon$ , 12,900), sh 340 ( $\epsilon$ , 7,000), 372 ( $\epsilon$ , 27,000), 391  $m\mu$  ( $\epsilon$ , 1,400).

*Anal.* Calcd. for  $C_{18}H_{16}N_2O_5$ : C, 63.53; H, 4.74; N, 8.23. Found: C, 63.71; H, 4.44; N, 8.52.

### 3,8-Dimethylbenzo[c]cinnoline (19) (15).

Two g. (0.006 mole) of 2,2'-dinitro-4,4'-dimethylbiphenyl (7) (21) in 200 ml. of absolute ethanol containing 4 ml. of 4% sodium hydroxide and Raney nickel W-6 was hydrogenated. After the uptake of 950 ml. of hydrogen the catalyst was filtered and the solution evaporated. The crystalline residue was filtered with suction, washed with methanol and dried, m.p. 184°. Recrystallization from ethanol (charcoal) gave 1.0 g. (65%) of yellow crystals, m.p. 187-188° (lit. (15) 188°).

*Anal.* Calcd. for  $C_{14}H_{12}N_2$ : C, 80.74; H, 5.81; N, 13.45. Found: C, 80.94; H, 5.87; N, 13.58.

### 3,8-Dimethylbenzo[c]cinnoline 5-Oxide (20) (15).

3,8-Dimethylbenzo[c]cinnoline (19) (250 mg.) in 25 ml. of acetic acid was stirred overnight after 1 ml. of 50% hydrogen peroxide had been added. Then 40 ml. of water was added, the precipitate filtered with suction, washed with water and dried to give 250 mg. of the monoxide, m.p. 207°. Recrystallization from ethanol gave 200 mg. (73%) of light yellow crystals, m.p. 207-208° (lit. (15) 208°).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O$ : C, 74.98; H, 5.39; N, 12.49. Found: C, 74.99; H, 5.50; N, 12.70.

### 2,9-Dimethylbenzo[c]cinnoline (21) (23).

Two g. (0.006 mole) of 2,2'-dinitro-5,5'-dimethylbiphenyl (8) (22) was hydrogenated in the same way as described for compound 19. Crude material (1.25 g.) was obtained, m.p. 189°. Recrystallization from ethanol using charcoal gave 1.1 g. (65%) light yellow crystals, m.p. 189-190° (lit. (23) 187°, 40% yield reported).

*Anal.* Calcd. for  $C_{14}H_{12}N_2$ : C, 80.74; H, 5.81; N, 13.45. Found: C, 80.80; H, 5.87; N, 13.47.

### 2,9-Dimethylbenzo[c]cinnoline 5-Oxide (22) (25).

2,9-Dimethylbenzo[c]cinnoline (21) (23) (250 mg.) was oxidized in the same way as described for compound 20. There was obtained 210 mg. (77%) of nearly colorless crystals, m.p. 201-202° (lit. (25) 202°, yield not given).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O$ : C, 74.98; H, 5.39; N, 12.49. Found: C, 74.84; H, 5.26; N, 12.61.

### 3,8-Dimethoxybenzo[c]cinnoline 5-Oxide (23).

Three g. (0.01 mole) of 2,2'-dinitro-4,4'-dimethoxybiphenyl (9) (24) in 700 ml. of absolute ethanol containing 3 ml. of 4%

sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 830 ml. of hydrogen (TLC) the reaction solution was filtered and evaporated to give 2.0 g. of crude material, m.p. 175°. Recrystallization from ethanol-water gave 1.5 g. (60%) of yellow needles, m.p. 184-185°; U.V.  $\lambda$  max (95% ethanol), sh 253 ( $\epsilon$ , 29,750), 260 ( $\epsilon$ , 32,100), sh 300 ( $\epsilon$ , 9,000), 334 ( $\epsilon$ , 4,850), 410 ( $\epsilon$ , 3,200), 430  $m\mu$  ( $\epsilon$ , 3,200).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O_3$ : C, 65.62; H, 4.72; N, 10.93. Found: C, 65.66; H, 4.77; N, 11.17.

### 2,9-Dimethoxybenzo[c]cinnoline 5-Oxide (24).

Three g. (0.01 mole) of 2,2'-dinitro-5,5'-dimethoxybiphenyl (10) was hydrogenated the same way as described for 23 to give 2.0 g. of crude material, m.p. 220°. Recrystallization from ethanol (charcoal) gave 1.5 g. (60%) of colorless crystals, m.p. 229-230.5°; U.V.  $\lambda$  max (95% ethanol) 242 ( $\epsilon$ , 17,600), 246 ( $\epsilon$ , 34,600), 259 ( $\epsilon$ , 31,600), sh 287 ( $\epsilon$ , 15,200), sh 296 ( $\epsilon$ , 15,300), 307 ( $\epsilon$ , 18,600), 354 ( $\epsilon$ , 13,200), 362 ( $\epsilon$ , 13,300), 381  $m\mu$  ( $\epsilon$ , 10,200).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O_3$ : C, 65.60; H, 4.72; N, 10.93. Found: C, 65.30; H, 4.89; N, 10.74.

### 2,9-Dimethoxybenzo[c]cinnoline (25).

When the reduction as described for 24 above was allowed to proceed for a longer period of time the monoxide (24) and the benzo[c]cinnoline (25) were formed. To isolate small amounts of the desired compound the reaction solution was evaporated to dryness then redissolved in chloroform-ethanol. The monoxide crystallized while the base remained in solution, thus, 2,9-dimethoxybenzo[c]cinnoline (25) could be isolated by evaporation and additional recrystallization from ethanol, m.p. 166-169°; U.V.  $\lambda$  max (95% ethanol), sh 235 ( $\epsilon$ , 22,300), 244 ( $\epsilon$ , 30,400), 255 ( $\epsilon$ , 32,000), 275 ( $\epsilon$ , 18,600), 330 ( $\epsilon$ , 8,500), 350  $m\mu$  ( $\epsilon$ , 7,700).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O_2$ : C, 69.99; H, 5.03; N, 11.66. Found: C, 70.00; H, 5.02; N, 11.48.

### 2,2'-Diamino-4,4'-Dicarbomethoxybiphenyl (26).

2,2'-Dinitro-4,4'-dicarbomethoxybiphenyl (3.6 g., 0.01 mole) (11) (21) was hydrogenated in 500 ml. of absolute ethanol with freshly prepared Raney nickel W-2 until 1440 ml. of hydrogen was absorbed. The mixture was filtered and evaporated to dryness to give after one additional recrystallization from ethanol (charcoal) 1.2 g. (40%) of colorless needles, m.p. 175-176°; U.V.  $\lambda$  max (95% ethanol), 232 ( $\epsilon$ , 49,300), 276 ( $\epsilon$ , 8,000), 333  $m\mu$  ( $\epsilon$ , 9,000).

*Anal.* Calcd. for  $C_{16}H_{16}N_2O_4$ : C, 63.99; H, 5.37; N, 9.33. Found: C, 64.15; H, 5.30; N, 9.07.

### 3,8-Dicarbomethoxybenzo[c]cinnoline (27).

To 2.5 g. (0.0083 mole) of 2,2'-diamino-4,4'-dicarbomethoxybiphenyl (26) in 75 ml. of acetic acid was added 4 ml. of 50% hydrogen peroxide and stirred at 25° for 18 hours. After 150 ml. of water was added the product was filtered with suction and dried to give 2.2 g. of crude material, m.p. 275-277° dec. Then the product was dissolved in chloroform and filtered over a column of neutral aluminum oxide Wölm (2 x 40 cm). The remaining product was eluted with chloroform. The solutions were evaporated to give 2.0 g. (80%) of white crystals, m.p. 284-285° dec.; U.V.  $\lambda$  max (95% ethanol), sh 205 ( $\epsilon$ , 1,400), sh 209 ( $\epsilon$ , 15,700), 217 ( $\epsilon$ , 19,000), 264 ( $\epsilon$ , 60,600), 280 ( $\epsilon$ , 35,500), sh 297 ( $\epsilon$ , 19,500), 315  $m\mu$  ( $\epsilon$ , 10,800).

*Anal.* Calcd. for  $C_{16}H_{12}N_2O_4$ : C, 64.86; H, 4.08; N, 9.45. Found: C, 64.62; H, 4.07; N, 9.28.

## 3,8-Dicarbomethoxybenzo[c]cinnoline 5-Oxide (28).

2,2'-Diamino-4,4'-dicarbomethoxybiphenyl (26) (1.5 g., 0.005 mole) in 150 ml. of acetic acid was stirred at room temperature with 4 ml. of 50% hydrogen peroxide for 4 hours. Then another 4 ml. of 50% hydrogen peroxide was added, the temperature was raised to 80° and maintained overnight. The crude material was isolated by adding 200 ml. of water and filtered, giving 1.4 g. of product, m.p. 240°. Purification was carried out in the same way as described for 27 to give 1.1 g. (86%) of colorless crystals, m.p. 248-250°; U.V.  $\lambda$  max (95% ethanol) 204 ( $\epsilon$ , 2,400), sh 218 ( $\epsilon$ , 19,300), sh 228 ( $\epsilon$ , 16,700), 261 ( $\epsilon$ , 41,300), 272 ( $\epsilon$ , 42,700), sh 282 ( $\epsilon$ , 35,400), 294 ( $\epsilon$ , 34,600), sh 309 ( $\epsilon$ , 15,500), sh 314 ( $\epsilon$ , 10,700), 345 ( $\epsilon$ , 7,700), 373 ( $\epsilon$ , 3,400), 391  $\mu$ m ( $\epsilon$ , 2,000).

*Anal.* Calcd. for  $C_{16}H_{12}N_2O_5$ : C, 61.54; H, 3.87; N, 8.97. Found: C, 61.38; H, 3.73; N, 9.09.

## 3,8-Diaminobenzo[c]cinnoline 5,6-Dioxide (31).

2,2'-Dinitro-4,4'-diaminobiphenyl (29) (2.7 g., 0.01 mole) in 250 ml. of absolute ethanol containing 5 ml. of 4% sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 480 ml. of hydrogen the precipitate and catalyst was filtered with suction and extracted with hot dimethylformamide. Ethanol was added to the solution and the mixture then kept in the refrigerator overnight to give 1.1 g. (40%) of red-violet crystals, m.p. > 270° dec.; U.V.  $\lambda$  max (95% ethanol), 222 ( $\epsilon$ , 1,200), 255 ( $\epsilon$ , 1,350), 305 ( $\epsilon$ , 36,300), sh 320 ( $\epsilon$ , 2,150), 496  $\mu$ m ( $\epsilon$ , 2,650).

*Anal.* Calcd. for  $C_{12}H_{10}N_4O_2$ : C, 59.50; H, 4.16; N, 23.13. Found: C, 59.69; H, 4.31; N, 22.70.

## 3,8-Bis(acetylamino)benzo[c]cinnoline 5,6-Dioxide (32).

One hundred mg. of 3,8-diaminobenzo[c]cinnoline 5,6-dioxide (31) was heated in 20 ml. of acetic anhydride while stirring for 30 minutes at 100°. The yellow product which was formed during this time was filtered with suction, washed with ethanol and dried, m.p. > 300°. Recrystallization from dimethylformamide gave 75 mg. (50%) of yellow powder, m.p. > 300°; U.V.  $\lambda$  max (95% ethanol) taken in a 10 cm. cell; sh 280 ( $\epsilon$ , 4,610), 310  $\mu$ m ( $\epsilon$ , 2,980).

*Anal.* Calcd. for  $C_{16}H_{14}N_4O_4$ : C, 58.89; H, 4.32; N, 17.17. Found: C, 58.47; H, 4.35; N, 16.82.

## 3,8-Bis(diethylamino)benzo[c]cinnoline 5,6-Dioxide (33).

2,2'-Dinitro-4,4'-bis(diethylamino)biphenyl (30) (1.8 g., 0.005 mole) (15) in 250 ml. of absolute ethanol which contained 3 ml. of 4% sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 240 ml. of hydrogen the solution was filtered, the residue extracted with chloroform and filtered. After the addition of ether, the warm solution was allowed to stand overnight in the refrigerator to give 0.8 g. (46%) of red-violet crystals, m.p. 233-234° dec.; U.V.  $\lambda$  max (95% ethanol), 230 ( $\epsilon$ , 16,100), 257 ( $\epsilon$ , 16,250), 319 ( $\epsilon$ , 59,250), 335 ( $\epsilon$ , 54,450), sh 350 ( $\epsilon$ , 37,300), 533 ( $\epsilon$ , 3,600); (cyclohexane) 205 ( $\epsilon$ , 20,900), 227 ( $\epsilon$ , 12,000), 260 ( $\epsilon$ , 16,000), 311 ( $\epsilon$ , 33,800), sh 322 ( $\epsilon$ , 33,500), 336 ( $\epsilon$ , 39,000), sh 354 ( $\epsilon$ , 23,500), sh 388 ( $\epsilon$ , 2,200), 470 ( $\epsilon$ , 3,500), 495  $\mu$ m ( $\epsilon$ , 2,400).

*Anal.* Calcd. for  $C_{20}H_{26}N_4O_2$ : C, 67.77; H, 7.39; N, 15.81. Found: C, 67.54; H, 7.47; N, 15.99.

## 3,8-Bis(diethylamino)benzo[c]cinnoline 5-Oxide (34).

3,8-Bis(diethylamino)benzo[c]cinnoline 5,6-dioxide (33) (0.9 g., 0.0025 mole) in 400 ml. of ethanol containing 2 ml. of 4% sodium hydroxide and Raney nickel W-7 was hydrogenated. After the uptake of 75 ml. of hydrogen the solution was filtered and

evaporated. The residue was dissolved in chloroform and chromatographed in a column (2 x 40 cm) of neutral alumina Wölm with chloroform-benzene (1:1) as eluent, yield 0.45 g. (50%) of red-violet crystals, m.p. 179-180°; U.V.  $\lambda$  max (95% ethanol), 303 ( $\epsilon$ , 14,500), sh 315 ( $\epsilon$ , 13,500), 338 ( $\epsilon$ , 56,400), sh 355 ( $\epsilon$ , 30,300), 519 ( $\epsilon$ , 3,150); (cyclohexane) 204 ( $\epsilon$ , 20,600), sh 247 ( $\epsilon$ , 21,000), 271 ( $\epsilon$ , 27,000), 311 ( $\epsilon$ , 49,700), sh 320 ( $\epsilon$ , 42,200), sh 349 ( $\epsilon$ , 25,500), 474 ( $\epsilon$ , 4,000), 497  $\mu$ m ( $\epsilon$ , 3,300).

*Anal.* Calcd. for  $C_{20}H_{26}N_4O$ : C, 70.98; H, 7.74; N, 16.55. Found: C, 70.68; H, 7.91; N, 16.70.

## 3,8-Bis(dimethylamino)benzo[c]cinnoline 5-Oxide (35) (15).

This compound was prepared using the method of Ullmann and Dieterle (15) with final purification as described for the preparation of 34, m.p. 242-244° (lit. 242°); U.V.  $\lambda$  max (95% ethanol) sh 303 ( $\epsilon$ , 13,700), sh 313 ( $\epsilon$ , 17,400), 336 ( $\epsilon$ , 49,400) sh 352 ( $\epsilon$ , 25,900), 519 ( $\epsilon$ , 2,900); (cyclohexane), 204 ( $\epsilon$ , 15,900), sh 245 ( $\epsilon$ , 15,400), 265 ( $\epsilon$ , 22,200), 307 ( $\epsilon$ , 34,700), sh 322 ( $\epsilon$ , 30,400), 343 ( $\epsilon$ , 18,100), sh 370 ( $\epsilon$ , 1,800), 460 ( $\epsilon$ , 2,900), sh 495  $\mu$ m ( $\epsilon$ , 1,800).

*Anal.* Calcd. for  $C_{16}H_{18}N_4O$ : C, 68.06; H, 6.43; N, 19.84. Found: C, 67.92; H, 6.55; N, 19.93.

## 3,8-Bis(dimethylamino)benzo[c]cinnoline (36) (15).

This compound was prepared from 35 using the method of Ullmann and Dieterle (15), m.p. 283-285° (lit. 270°); U.V.  $\lambda$  max (95% ethanol), 213 ( $\epsilon$ , 18,100), 290 ( $\epsilon$ , 88,000), sh 336 ( $\epsilon$ , 20,300), 498 ( $\epsilon$ , 3,150); (cyclohexane), 211 ( $\epsilon$ , 23,950), 280 ( $\epsilon$ , 69,250), 305 ( $\epsilon$ , 25,500), sh 320 ( $\epsilon$ , 17,150), 450  $\mu$ m ( $\epsilon$ , 2,600).

*Anal.* Calcd. for  $C_{16}H_{18}N_4$ : C, 72.15; H, 6.81; N, 21.04. Found: C, 72.10; H, 6.67; N, 21.24.

## 3,8-Dimethoxybenzo[c]cinnoline (37) (24).

One hundred mg. of 3,8-dimethoxybenzo[c]cinnoline 5,6-dioxide (15) was heated for 5 minutes in 20 ml. of 50% hydriodic acid. Water was added to the dark solution. The precipitate was filtered and recrystallized from ethanol to give 35 mg. (40%) of yellow needles, m.p. 197° (lit. (24) 197°); U.V.  $\lambda$  max (95% ethanol) sh 220 ( $\epsilon$ , 13,300), 259 ( $\epsilon$ , 74,100), sh 290 ( $\epsilon$ , 10,000), 311 ( $\epsilon$ , 6,700), 400 ( $\epsilon$ , 3,200); (0.1 N hydrochloric acid) 205 ( $\epsilon$ , 24,400), sh 220 ( $\epsilon$ , 19,100), 272 ( $\epsilon$ , 45,100), 352 ( $\epsilon$ , 11,800), 475  $\mu$ m ( $\epsilon$ , 3,300).

*Anal.* Calcd. for  $C_{14}H_{12}N_2O_2$ : C, 69.99; H, 5.02; N, 11.66. Found: C, 69.59; H, 5.04; N, 11.46.

## 2,2'-Dinitro-4,4'-diacetoxybiphenyl (38).

Copper powder (22 g.) (Matheson, Coleman and Bell) was added slowly with stirring to 30.5 g. of 3-nitro-4-iodoacetoxybenzene (26) at 140°. The temperature was raised to 180° and kept at this point for 1 hour. The crude material was obtained by extraction with benzene followed by evaporation to dryness. Methanol was added to the residue and the suspension was filtered. Recrystallization gave 14 g. (77%) of light yellow crystals, m.p. 164-166°; U.V.  $\lambda$  max (95% ethanol), 219 ( $\epsilon$ , 33,200), sh 261 ( $\epsilon$ , 11,400), sh 305  $\mu$ m ( $\epsilon$ , 4,000).

*Anal.* Calcd. for  $C_{16}H_{12}N_2O_8$ : C, 53.34; H, 3.36; N, 7.78. Found: C, 53.21; H, 3.40; N, 7.93.

## 2,2'-Dinitro-4,4'-dihydroxybiphenyl (39).

2,2'-Dinitro-4,4'-diacetoxybiphenyl (38) (18 g.) was suspended in 250 ml. of 50% sulfuric acid and the suspension was heated for 1.5 hours during which time ethanol was added to insure homogeneity. The excess ethanol was removed by evaporation. After cooling 12 g. of crude material was isolated. Recrystallization

from ethanol-water (charcoal) gave 10 g. (70%) of yellow needles, m.p. 202-203°; U.V.  $\lambda$  max (95% ethanol), 218 ( $\epsilon$ , 28,000) sh 235 ( $\epsilon$ , 24,200), sh 273 ( $\epsilon$ , 7,000), sh 340  $m\mu$  ( $\epsilon$ , 4,400).

*Anal.* Calcd. for  $C_{12}H_8N_2O_6$ : C, 52.18; H, 2.92; N, 10.14. Found: C, 52.24; H, 2.95; N, 10.15.

#### 2,2'-Dinitro-4,4'-bis(tetrahydro-2-pyraniloxy)biphenyl (40).

Two g. (0.0045 mole) of 2,2'-dinitro-4,4'-dihydroxybiphenyl (39) in 50 ml. of chloroform, 2.5 g. of tetrahydropyran and a catalytic amount of *p*-toluenesulfonic acid was stirred for 5 hours at 25°. The mixture then was passed through a column of neutral alumina Wölm (2 x 40 cm) and eluted with chloroform. After evaporation, methanol was added and the solution was allowed to stand in the refrigerator overnight. The product (1.9 g.) m.p. 125° dec., was isolated and recrystallized by dissolving in chloroform and adding ether to the warm solution. The product was dried *in vacuo* at 25° to give 1.7 g. (53%) of yellow needles, m.p. 130-131° dec.; U.V.  $\lambda$  max (95% ethanol), 225 ( $\epsilon$ , 30,300), sh 268 ( $\epsilon$ , 12,200), sh 325  $m\mu$  ( $\epsilon$ , 4,000).

*Anal.* Calcd. for  $C_{22}H_{24}N_2O_8$ : C, 59.46; H, 5.44; N, 6.30. Found: C, 59.27; H, 5.66; N, 6.23.

#### 3,8-Bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline 5,6-Dioxide (41) and 3,8-Bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline 5-Oxide (42).

2,2'-Dinitro-4,4'-bis(tetrahydro-2-pyraniloxy)biphenyl (40) (1.35 g., 0.003 mole) was dissolved in 20 ml. of tetrahydrofuran to which was added 140 ml. of absolute ethanol, 2 ml. of 4% sodium hydroxide and Raney nickel W-6 and the mixture hydrogenated. After the uptake of 380 ml. of hydrogen the reaction mixture was filtered and the residue extracted with chloroform. Upon evaporation to dryness, 1.0 g. of crude material was obtained which was a mixture of the dioxide (41) and the monoxide (42). Purification was accomplished by preparative TLC on alumina (PF<sub>254</sub> Merck) 2 mm. thick. Eight plates 20 cm. in length were required using chloroform-benzene (1:1). The fractions were eluted with warm chloroform-methanol and evaporated to dryness to give 0.5 g. (40%) of the yellow crystalline dioxide (41), m.p. 189-190° dec., as the first fraction; U.V.  $\lambda$  max (95% ethanol) sh 224 ( $\epsilon$ , 11,500); sh 242 ( $\epsilon$ , 19,300); 266 ( $\epsilon$ , 47,500), 283 ( $\epsilon$ , 38,500), 350 ( $\epsilon$ , 9,950), 404 ( $\epsilon$ , 3,200), 425  $m\mu$  ( $\epsilon$ , 3,100).

*Anal.* Calcd. for  $C_{22}H_{24}N_2O_6$ : C, 64.07; H, 5.87; N, 6.79. Found: C, 64.32; H, 5.89; N, 6.57.

The second fraction (0.2 g., 20%) was the yellow crystalline monoxide (42), m.p. 169-170° dec.; U.V.  $\lambda$  max (95% ethanol), 208 ( $\epsilon$ , 20,300), sh 250 ( $\epsilon$ , 46,000), 261 ( $\epsilon$ , 50,100), sh 298 ( $\epsilon$ , 16,900), 335 ( $\epsilon$ , 18,500), 402 ( $\epsilon$ , 4,500), 420  $m\mu$  ( $\epsilon$ , 4,200).

*Anal.* Calcd. for  $C_{22}H_{24}N_2O_5$ : C, 66.65; H, 6.10; N, 7.07. Found: C, 66.73; H, 5.89; N, 6.98.

#### 3,8-Bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline (43).

2,2'-Dinitro-4,4'-bis(tetrahydro-2-pyraniloxy)biphenyl (40) (1.8 g., 0.004 mole) was dissolved in 40 ml. of tetrahydrofuran. To the solution was added 310 ml. of ethanol, 1.5 ml. of 4% sodium hydroxide and Raney nickel W-6 and hydrogenated until 500 ml. hydrogen was absorbed. Further hydrogenation was carried out by adding additional Raney nickel W-7. The reaction was stopped after the uptake of another 180 ml. of hydrogen. The mixture was filtered, evaporated to dryness, some methanol was added, filtered with suction and washed with methanol. The product (0.95 g.) contained a little monoxide (42), the base (43) and an unidentified compound, probably the amine. Purification by preparative TLC as described for 41 gave 0.4 g. (26%) of

yellow crystals, m.p. 188-189° dec.; U.V.  $\lambda$  max (95% ethanol), 202 ( $\epsilon$ , 28,000), sh 218 ( $\epsilon$ , 12,600), 257 ( $\epsilon$ , 7,110), sh 287 ( $\epsilon$ , 13,500), 309 ( $\epsilon$ , 7,200), 392  $m\mu$  ( $\epsilon$ , 2,800).

*Anal.* Calcd. for  $C_{22}H_{24}N_2O_4$ : C, 69.46; H, 6.36; N, 7.36. Found: C, 69.69; H, 6.30; N, 7.33.

#### 3,8-Dihydroxybenzo[c]cinnoline 5,6-Dioxide (44).

Two hundred mg. of 3,8-bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline 5,6-dioxide (41) was stirred in 100 ml. of 95% ethanol containing 0.1 ml. of concentrated hydrochloric acid for 10 hours. The precipitate was filtered with suction, washed with ethanol and dried to give 109 mg. (87%) of yellow microcrystalline material, m.p. > 300° dec.; U.V.  $\lambda$  max (95% ethanol), sh 221 ( $\epsilon$ , 21,400), sh 243 ( $\epsilon$ , 23,700), sh 255 ( $\epsilon$ , 33,700), 267 ( $\epsilon$ , 44,000), 286 ( $\epsilon$ , 30,000), 329 ( $\epsilon$ , 9,500), 348 ( $\epsilon$ , 8,600), 431 ( $\epsilon$ , 3,900); (0.1 *N* sodium hydroxide) 214 ( $\epsilon$ , 45,300), sh 256 ( $\epsilon$ , 47,000), sh 275 ( $\epsilon$ , 62,700), 297 ( $\epsilon$ , 58,800), 358 ( $\epsilon$ , 5,900), 529  $m\mu$  ( $\epsilon$ , 3,900).

*Anal.* Calcd. for  $C_{12}H_8N_2O_4$ : C, 59.02; H, 3.30; N, 11.47. Found: C, 59.13; H, 3.32; N, 11.29.

#### 3,8-Dihydroxybenzo[c]cinnoline 5-Oxide (45).

(a) 2,2'-Dinitro-4,4'-dihydroxybiphenyl (39) (1.4 g., 0.005 mole) was dissolved in 100 ml. of 50% ethanol containing 450 mg. of sodium hydroxide and hydrogenated with Raney nickel W-7. After the uptake of 240 ml. of hydrogen the violet solution was filtered and acidified with acetic acid. Yellow material separated and was filtered with suction, washed with water and dried to give 0.8 g. of the crude material. After recrystallization from ethanol 0.7 g. (56%) of yellow microcrystalline material was obtained, m.p. > 300° dec.

*Anal.* Calcd. for  $C_{12}H_8N_2O_3$ : C, 63.16; H, 3.53; N, 12.28. Found: C, 63.02; H, 3.64; N, 12.15.

(b) Two hundred mg. of 3,8-bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline 5-oxide (42) was stirred with 100 ml. of 95% ethanol containing 0.1 ml. of concentrated hydrochloric acid at 25°. After 10 hours the precipitate was filtered with suction, washed with ethanol and dried to give 101 mg. (88%) of a yellow microcrystalline material, m.p. > 300°; U.V.  $\lambda$  max (95% ethanol) sh 235 ( $\epsilon$ , 21,700), sh 252 ( $\epsilon$ , 44,900), 260 ( $\epsilon$ , 45,200), sh 301 ( $\epsilon$ , 14,500), 327 ( $\epsilon$ , 9,000), sh 357 ( $\epsilon$ , 4,400), 430 ( $\epsilon$ , 4,400); (0.1 *N* sodium hydroxide) sh 213 ( $\epsilon$ , 28,100), sh 243 ( $\epsilon$ , 22,000), 286 ( $\epsilon$ , 59,700), 323 ( $\epsilon$ , 14,500), sh 356 ( $\epsilon$ , 5,300), 521  $m\mu$  ( $\epsilon$ , 3,700).

*Anal.* Calcd. for  $C_{12}H_8N_2O_3$ : C, 63.16; H, 3.53; N, 12.28. Found: C, 63.12; H, 3.62; N, 12.13.

#### 3,8-Dihydroxybenzo[c]cinnoline (46).

Two hundred mg. of 3,8-bis(tetrahydro-2-pyraniloxy)benzo[c]cinnoline (43) was stirred overnight with 25 ml. of 95% ethanol containing 0.1 ml. of concentrated hydrochloric acid at 25°. After cooling in the refrigerator the red precipitate was filtered with suction and dried to give 90 mg. of the hydrochloride salt. The material was dissolved in ethanol-water and a few drops of diluted ammonia solution were added until the solution turned yellow in color; the solution then was heated to remove the ethanol and cooled to give 70 mg. (70%) of yellow needles, m.p. > 300° dec.; U.V.  $\lambda$  max (95% ethanol) 202 ( $\epsilon$ , 30,600), 219 ( $\epsilon$ , 12,800) 250 ( $\epsilon$ , 66,100), sh 277 ( $\epsilon$ , 14,600), sh 295 ( $\epsilon$ , 8,400), sh 317 ( $\epsilon$ , 4,800), 420 ( $\epsilon$ , 3,200); (0.1 *N* sodium hydroxide) sh 230 ( $\epsilon$ , 28,700), sh 255 ( $\epsilon$ , 17,400), 280 ( $\epsilon$ , 83,200), sh 300 ( $\epsilon$ , 24,500), 497 ( $\epsilon$ , 3,200); (0.1 *N* hydrochloric acid) 206 ( $\epsilon$ , 21,100), sh 222 ( $\epsilon$ , 16,900), 272 ( $\epsilon$ , 56,100), 350 ( $\epsilon$ , 9,400), 490  $m\mu$  ( $\epsilon$ , 2,500).

*Anal.* Calcd. for  $C_{12}H_8N_2O_2$ : C, 67.92; H, 3.80; N, 13.20.



Found: C, 67.71; H, 3.69; N, 12.92.

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