534. *New Syntheses of Heterocyclic Compounds. Part XI.* 2 : 9 : 10-*Triaza-anthracenes.*

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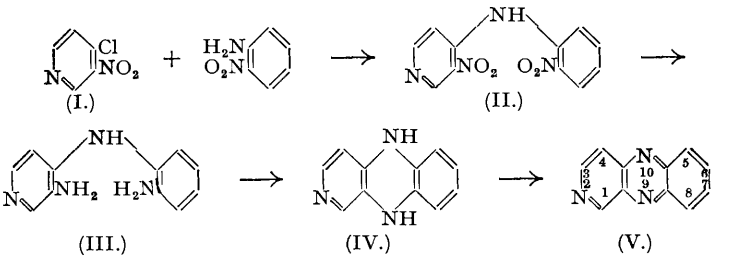
Condensation of 4-chloro-3-nitropyridine hydrochloride (I) with 2-nitroaniline gives 3-*nitro*-4-o-*nitroanilinopyridine* (II), which is then reduced to the *diamino*-compound (III). Heating the *dihydrochloride* of (III) gives 9 : 10-*dihydro*-2 : 9 : 10-*triaza-anthracene hydrochloride monohydrate* (cf. IV), from which 2 : 9 : 10-*triaza-anthracene* (V) is obtained by oxidation. 4-*Methyl*-2 : 9 : 10-*triaza-anthracene* is similarly prepared, but attempts to obtain other substituted 2 : 9 : 10-triaza-anthracenes were not successful.

The synthesis of a *x* : 9 : 10-triaza-anthracene (azaphenazine) was first recorded by Peratoner (*Gazzetta*, 1911, **41**, 662) who prepared 4-hydroxy-2 : 9 : 10-triaza-anthracene by direct condensation of triketotetrahydropyridine with *o*-phenylenediamine. Some twenty-five years later Tschitschibabin and Kirsanov (*Ber.*, 1927, **60**, 766) obtained a 5 : 6 : 7 : 8-dibenz-1 : 9 : 10-triaza-anthracene from 2 : 3-diaminopyridine and phenanthraquinone, a reaction subsequently applied to 3 : 4-diaminopyridine by Koenigs, Bueren, and Jung (*ibid.*, 1936, **69**, 2690). More recently Petrow and Saper (*J.*, 1946, 588) prepared 4-nitro-10-phenyl-9 : 10-dihydro-2 : 9 : 10-triaza-anthracene (1-nitro-5-phenyldihydro-3-azaphenazine) by removal of the elements of nitrous acid from *N*-phenyl-*N'*-(3 : 5-dinitro-4-pyridyl)-*o*-phenylenediamine. None of these methods appeared capable of much extension and, in seeking new routes to compounds of this type, we turned our attention to the ring closure of aza-2 : 2'-diaminodiphenylamines.

The conversion of a diaminodiphenylamine into a phenazine was first accomplished by Ullmann (*Annalen*, 1909, **366**, 91), who found that 2 : 4-dinitro-2'-aminodiphenylamine-6-carboxylic acid underwent ring closure and simultaneous decarboxylation to yield 2-amino-phenazine when reduced with stannous chloride in hydrochloric acid. Eckert and Steiner (*Monatsh.*, 1914, **35**, 1154) extended these observations by examining the reduction of 2 : 2'-dinitrodiphenylamine with stannous chloride in hydrochloric acid. Their results showed that a " quinhydrone " type of compound composed of phenazine and dihydrophenazine was formed, which passed into phenazine on oxidation. The reaction was investigated afresh by Tomlinson (*J.*, 1939, 158) who found that the intermediate 2 : 2'-diaminodiphenylamines could be isolated and converted into phenazine by mild oxidation with ferric chloride or hydrogen peroxide. Essentially the same route was employed by Koenigs and Jung (*J. pr. Chem.*, 1933, **137**, 141) for the preparation of 2 : 7 : 9 : 10-tetra-aza-anthracene, but in this case the intermediate di-(3-nitro-4-pyridyl)amine (dihydrochloride) was converted into 9 : 10-dihydro-2 : 7 : 9 : 10-tetra-aza-anthracene in 97% yield by prolonged heating in a sealed tube at 215°; oxidation with hydrogen peroxide or ferric chloride gave the aromatic compound.



(I.) (II.) (III.) (IV.) (V.)

The behaviour of 3-*amino*-4-o-*nitroanilinopyridine* (III) closely followed the above reaction pattern. (III) was obtained by condensation of 4-chloro-3-nitropyridine hydrochloride (I) with *o*-nitroaniline in glacial acetic acid, followed by reduction of the resulting *dinitro-amine* (II) with reduced iron in acidulated aqueous methanol. Although yields of (III) as high as 80% were sometimes obtained, on other occasions the reductions appeared to fail completely. By immediately treating the reduction products *in situ* with ethanolic hydrochloric acid, however, reproducible yields of the *dihydrochloride* of (III) were readily obtained. Attempts to prepare (III) by reducing (II) with aqueous sodium sulphide only gave a *nitro-amino*-compound.

Conversion of (III) into (V) by direct oxidation as described by Tomlinson (*loc. cit.*) was not successful. Heating the hydrochloride of (III) in a sealed tube, followed by extraction with alcohol, however, readily yielded 9 : 10-*dihydro*-2 : 9 : 10-*triaza-anthracene hydrochloride monohydrate* (cf. IV) in excellent yield. Further work proved the sealed tube to be unnecessary,

conversion into the dihydrophenazine taking place on merely heating the hydrochloride of (III) to its decomposition point for 2 minutes. Addition of aqueous ammonia to an aqueous solution of the hydrochloride of (IV) precipitated an unstable yellow solid which passed smoothly into 2 : 9 : 10-*triaza-anthracene* (V) on oxidation with hydrogen peroxide.

Extension of the method to 3-nitro-*p*-toluidine (Me = 1) gave 3-*nitro*-4-(3-*nitro*-o-*toluidino*)-*pyridine*, and thence by reduction and cyclisation etc., 7-*methyl*-2 : 9 : 10-*triaza-anthracene*. 2-Nitro-*p*-anisidine (NH_2 = 1) gave 3-*nitro*-4-(2-*nitro*-p-*anisidino*)*pyridine*, reduced to 3-*amino*-4-(2-*amino*-p-*anisidino*)*pyridine*, but preliminary attempts at the ring closure of the latter compound proved unsuccessful. 2-Nitro-1-naphthylamine gave 3-*nitro*-4-(2-*nitro*-1-*naphthylamino*)*pyridine* mixed with aceto-2-nitro-1-naphthalide, but the yield was so low as to preclude further work. 1-Nitro-2-naphthylamine failed to condense with (I).

Experimental.

M. p.s are corrected. Microanalyses are by Drs. Weiler and Strauss, Oxford.

3-*Nitro*-4-o-*nitroanilinopyridine* (II).—4-Chloro-3-nitropyridine hydrochloride (12 g.) (Koenigs and Fulde, *Ber.*, 1927, **60**, 2107) and *o*-nitroaniline (8·5 g.) dissolved in glacial acetic acid (80 ml.) were heated under reflux for about 5 hours whereafter evolution of hydrogen chloride had ceased. The mixture was cooled and made alkaline with aqueous ammonia (*d* 0·880), and the precipitated solids were crystallised from alcohol, giving golden-yellow needles of 3-*nitro*-4-o-*nitroanilinopyridine* (45%), m. p. 171·5—173·5° (Found : C, 50·5; H, 3·1; N, 21·2. $C_{11}H_8O_4N_4$ requires C, 50·8; H, 3·1; N, 21·5%).

3-*Amino*-4-o-*aminoanilinopyridine* (III).—The forgoing nitro-compound (4 g.), reduced iron (12 g.), methanol (25 ml.), water (5 ml.), and concentrated hydrochloric acid (0·5 ml.) were heated under reflux for 1 hour. The resulting mixture was extracted with methanol, and the bulked filtrates were concentrated until crystallisation commenced. The *product* formed reddish-brown needles (80%) (from aqueous methanol), m. p. 144—146° (Found : C, 66·0; H, 6·6; N, 27·6. $C_{11}H_{12}N_4$ requires C, 66·0; H, 6·0; N, 28·0%). When ethanolic hydrochloric acid was added to a hot ethanolic solution of the base, the *dihydrochloride monohydrate* separated on cooling; it formed white needles, m. p. 283—284°, from ethanol (Found : Cl, 24·8. $C_{11}H_{12}N_4,2HCl,H_2O$ requires Cl, 24·4%).

3-*Nitro*(*or* 3-*amino*)-4-o-*amino*(*or nitro*)*anilinopyridine*.—3-Nitro-4-*o*-nitroanilinopyridine (2 g.) was added in small portions to a hot solution of sodium sulphide (7 g.) in water (40 ml.), and the red solution boiled under reflux for 15 minutes. The solids which separated on cooling were collected and crystallised from aqueous methanol, giving the *nitro-amino*-compound in long, thin blood-red needles, m. p. 154—155° (Found : C, 57·0; H, 4·5; N, 24·6. $C_{11}H_{10}O_2N_4$ requires C, 57·4; H, 4·3; N, 24·4%).

9 : 10-*Dihydro*-2 : 9 : 10-*triaza-anthracene Hydrochloride Monohydrate*.—The dihydrochloride (1·5 g.) of (III) was heated at its decomposition point (283—284°) for 2 minutes. After cooling, the orange product was extracted with alcohol, giving 9 : 10-*dihydro*-2 : 9 : 10-*triaza-anthracene hydrochloride monohydrate* as small red needles (58%) (from ethanol), m. p. 290° (Found : C, 55·7; H, 5·2; N, 17·6. $C_{11}H_{10}N_3Cl,H_2O$ requires C, 55·6; H, 5·1; N, 17·7%).

2 : 9 : 10-*Triaza-anthracene* (V).—Aqueous ammonia (12 ml.; *d* 0·880) was added to a solution of the foregoing hydrochloride monohydrate (1 g.) in hot water (25 ml.). A yellow solid separated which soon assumed a characteristic blue colour. It was immediately dissolved by warming the suspension with alcohol (20 ml.). Hydrogen peroxide (4 ml. of 100 vol.) was then added to the bluish-green solution, and the mixture boiled for a few minutes, the colour changing to dark orange. The mixture was evaporated until crystallisation commenced giving 2 : 9 : 10-*triaza-anthracene*, thick lemon-yellow needles (52%) (from light petroleum), m. p. 181—182° (Found : C, 72·7; H, 3·9; N, 23·6. $C_{11}H_7N_3$ requires C, 72·9; H, 3·8; N, 23·2%).

3-*Nitro*-4-(3-*nitro*-o-*toluidino*)*pyridine*.—Prepared (77%) from 4-chloro-3-nitropyridine hydrochloride (12 g.) and 3-nitro-*p*-toluidine (10 g.) under reflux in glacial acetic acid (100 ml.), this *compound* formed orange needles (from benzene), m. p. 195—196° (Found : C, 52·4; H, 3·7; N, 20·3. $C_{12}H_{10}O_4N_4$ requires C, 52·6; H, 3·6; N, 20·4%).

3-*Amino*-4-(3-*amino*-o-*toluidino*)*pyridine*.—The foregoing dinitro-compound (4 g.), reduced iron (12 g.), alcohol (30 ml.), water (10 ml.), and ferric chloride (1 g.) were boiled under reflux for 1 hour. The resulting mixture was extracted with alcohol, and the product separated from the filtrate after evaporation. Crystallisation from alcohol and from ethanol–light petroleum (b. p. 80—100°) yielded 3-*amino*-4-(3-*amino*-o-*toluidino*)*pyridine hydrochloride sesquihydrate* (49%), needles, m. p. 276—278° (decomp.) (Found : Cl, 12·7. $C_{12}H_{14}N_4,HCl,1\frac{1}{2}H_2O$ requires Cl,12·8%). By treating a concentrated aqueous solution of this hydrochloride with sodium hydroxide solution, the *base* was obtained, needles [from ethanol–light petroleum (b. p. 100—120°)], m. p. 161—162° (Found : C, 67·1; H, 6·5; N, 25·9. $C_{12}H_{14}N_4$ requires C, 67·3; H, 6·5; N, 26·2%).

7-*Methyl*-2 : 9 : 10-*triaza-anthracene*.—The foregoing dihydrochloride (1·8 g.) was heated at its m. p. over a naked flame for about 2 minutes. The orange-red product was immediately dissolved in hot water (30 ml.) and aqueous ammonia (2 ml.; *d* 0·880) added. The white solid which separated was immediately dissolved in alcohol, hydrogen peroxide (3 ml. of 100 vol.) added, and the dark orange mixture evaporated until a black oil began to separate. After cooling the black solids were collected and extracted with light petroleum (b. p. 40—60°) giving 7-*methyl*-2 : 9 : 10-*triaza-anthracene*, rosettes of lemon-coloured needles (from aqueous alcohol), m. p. 148° (Found : C, 73·9; H, 4·8; N, 21·3. $C_{12}H_6N_3$ requires C, 73·9; H, 4·6; N, 21·5%).

3-*Nitro*-4-(2-*nitro*-p-*anisidino*)*pyridine*.—Prepared (46%) by heating 4-chloro-3-nitropyridine hydrochloride (12 g.) and 2-nitro-*p*-anisidine (10 g.) in glacial acetic acid (100 ml.) under reflux for 5 hours, this *nitro*-compound formed orange needles (from benzene–light petroleum), m. p. 162—163° (Found : C, 49·8; H, 3·8; N, 19·4. $C_{12}H_{10}O_5N_4$ requires C, 49·7; H, 3·4; N, 19·3%).

3-*Amino*-4-(2-*amino*-p-*anisidino*)*pyridine*.—Prepared by reducing the forgoing dinitro-compound (1 g.) with reduced iron (3 g.) in alcohol (15 ml.), water (5 ml.), and ferric chloride (1 g.) under reflux for 1½ hours, this *compound* formed small flat needles [from ethanol–light petroleum (b. p. 100—120°)], m. p. 195° (Found : C, 62·6; H, 6·1. $C_{12}H_{14}ON_4$ requires C, 61·8; H, 5·8%).

3-*Nitro*-4-(2-*nitro*-1-*naphthylamino*)*pyridine*.—2-Nitro-1-naphthylamine (5·4 g.), 4-chloro-3-nitropyridine hydrochloride (5·6 g.), and acetic acid (50 ml.) were heated under reflux for 5 hours, and the cooled mixture was made alkaline with dilute aqueous ammonia. The precipitated solids were fractionated from alcohol, giving 3-*nitro*-4-(2-*nitro*-1-*naphthylamino*)*pyridine*, orange needles (20%) (from benzene), m. p. 202—204° (Found : C, 58·3; H, 3·2; N, 17·5. $C_{15}H_{10}O_4N_4$ requires C, 58·1; H, 3·2; N, 18·1%). The alcoholic mother-liquors yielded aceto-2-nitro-1-naphthalide, identified by its m. p. and mixed m. p. with an authentic specimen.

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