BENZINDOLES

IV*. SYNTHESIS OF 5,6,7,8-TETRAHYDROBENZO[*f*]INDOLE

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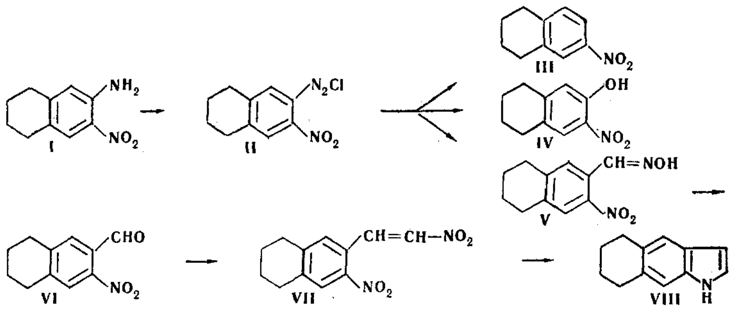
UDC 547.759.3.07

By the Nenitzescu reductive cyclization of o,ω-dinitrostyrenes, 5,6,7,8-tetrahydrobenzo-[*f*]indole has been obtained from 3-nitro-2-(β-nitrovinyl)-5,6,7,8-tetrahydronaphthalene.

Of the benzindoles, the angular isomers have been the best studied, since the use of general methods for the synthesis of indole compounds leads, as a rule, to benzindoles with the benzene rings coupled in the 4,5- or the 6,7-positions [1,2]. Substituted linear benzindoles can be obtained by the same methods if the active α position in the naphthyl radical of the β-naphthyl hydrazone of the appropriate carbonyl compounds is blocked or if the difficultly accessible β, β'-substituted naphthalenes are used as the starting materials [4,5]. Unsubstituted 5,6-benzindole itself has not hitherto been obtained except by the photochemical decomposition of quinone diazides [6].

In the present work we used for the synthesis of 5,6,7,8-tetrahydrobenzo[*f*]indole the classical method of constructing indole systems by Nenitzescu reductive cyclization. As the intial compound we used 3-nitro-5,6,7,8-tetrahydro-2-naphthaldehyde (VI), which we obtained from 3-nitro-5,6,7,8-tetrahydro-2-naphthylamine (I) by replacing the amino group by a formyl group. In agreement with the analogies existing in the literature [7,8], diazotization followed by coupling the diazo compound II with formaldehyde oxime and hydrolysis of the oxime V took place unambiguously. In addition to the aldehyde VI, isolated through the bisulfite derivative with a yield of 30 %, the reaction products were 2-nitrotetralin [9] (III) and 2-hydroxy-3-nitrotetralin (IV).

The structure of the aldehyde VI was confirmed by spectroscopy. The hydrolysis of the intermediate oxime V, without previous isolation was carried out with iron-ammonium alum and ferric sulfate. In the latter case, the reaction did not take place completely, but we succeeded in isolating and characterizing the pure oxime V. On being heated with pyruvic acid the latter was smoothly converted into the aldehyde VI.



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*For Communication III, see [2].

Mendeleev Moscow Chemical and Technological Institute. Translated from Khimiya Geterotsiklicheskikh Soedinenii, Vol. 6, No. 8, pp. 1083-1085, August, 1970. Original article submitted September 11, 1969.

The condensation of 3-nitro-5,6,7,8-tetrahydro-2-naphthaldehyde with nitromethane in the presence of ammonium acetate led to 3-nitro-2-(β-nitrovinyl)-5,6,7,8-tetrahydronaphthalene (VII) with a yield of 60 %. From the presence in the IR spectrum of bands of the nonplanar deformation vibrations of the hydrogen atoms of the vinyl group at 930 and 960 cm^{-1}, it may be concluded that compound VII exists in the trans form [10].

Reductive cyclization was carried out with iron powder in an ethanolic solution of acetic acid. The 5,6,7,8-tetrahydrobenzo[*f*]indole (VIII) formed was purified by vacuum sublimation and subsequent crystallization from light petroleum ether. On standing, the indole VII rapidly oxidized. Its mass spectrum (taken on an MKh-1103 instrument at 170°C) exhibited the simplicity that is characteristic for indole itself [11]. In this spectrum, the maximum peak was the peak of the molecular ion with m/e 171 and the second-strongest peak (~50%) (M-27) 143 was the result of the energetically favorable process of the elimination of HCN. The presence in the spectrum of three peaks with m/e 115, 116, and 117, each with an intensity of 10 % of the molecular peak, also permits this compound to be assigned to the indole series [11].

The PMR spectrum* of compound VIII exhibited signals of protons in the 6.20 and 6.62 ppm which we ascribed, in accordance with literature data [12], to the β- and α-protons of the pyrrole part of the molecule. The protons of the benzene ring have chemical shifts in the 7.13 and 6.50 ppm regions. The broadened signal of the proton attached to the nitrogen atom is present at 6.90 ppm. The signals of the protons of the aliphatic part of the molecule are present in the strong-field region (δ 2.81 and 1.78 ppm). The positions of all these signals confirm the structure as 5,6,7,8-tetrahydrobenzo[*f*]indole.

EXPERIMENTAL

3-Nitro-5,6,7,8-tetrahydro-2-naphthaldehyde (VI). With stirring, 20 g (~ 0.1 mole) of 3-nitro-5,6,7,8-tetrahydro-2-naphthylamine (I) [13] was suspended in a mixture of 23 ml of concentrated hydrochloric acid, 20 ml of water, and 40 g of ice. Then a solution of 7.54 g (0.11 mole) of sodium nitrite in 10 ml of water was slowly added at 0-5°C, and the mixture was stirred for another 30 min and was filtered through a glass filter (the amine residue amounted to 4.4 g). The filtrate was treated with a solution of 12.5 g of sodium acetate in 20 ml of water to neutrality. A mixture of 14.5 ml of 35% formalin solution and 11.9 g of hydroxylamine hydrochloride in 70 ml of water was heated until a clear solution had been obtained. Then 22.2 g of sodium acetate was added and the mixture was heated at 90-95°C for 15-20 min, cooled to 10°C, and treated with 0.44 g of sodium sulfate, 4.4 g of hydrated copper sulfate, and a solution of 71.75 g of sodium acetate in 78 ml of water. With vigorous stirring, a solution of the 3-nitro-5,6,7,8-tetrahydronaphthalene-2-diazonium chloride prepared above and cooled to 0°C was added to the resulting solution of formaldehyde oxime. The liberated nitrogen caused very pronounced foaming, and the oxime V precipitated in the form of a dark brown resin forming a large clot. After the addition, stirring was continued for another 1 hr and then the mixture was acidified to Congo red with concentrated hydrochloric acid and the liquid layer was separated from the resinous oxime by decantation. The oxime was treated with 42 g of iron ammonium alum in 100 ml of water. The mixture was heated under reflux for 40 min and distilled with steam. The first fractions of distillate contained considerable amounts of 2-nitrotetralin (III) and of 2-hydroxy-3-nitrotetralin (IV), which were separated by treating the ethereal extracts with 40 % sodium bisulfite solution. The bisulfite derivative was decomposed by being boiled with 2N sulfuric acid, and the aldehyde VI was filtered off, washed with water, and dried. Yield 5.3 g (30 %), mp 87-88°C (from ethanol). R_f 0.72 (benzene; here and below alumina of activity grade II was used and the spots were revealed with iodine). UV spectrum λ_{max} 236, 274-280 nm; log ε 4.02, 3.71 (in ethanol). IR spectrum, cm^{-1}: 1695 (C=O), 1535, 1345 (NO_2) (in paraffin oil). Found, %: C 64.25; H 5.41; N 6.74. Calculated for $C_{11}H_{11}NO_3$, % : C 64.38; H 5.40; N 6.82.

After the separation of the bisulfite derivative, the ethereal solutions were evaporated in vacuum and the residue was chromatographed on a column of alumina. Elution was carried out first with petroleum ether, giving, after the distillation of the solvent, the nitro compound III, mp 31.4°C [9]. Then elution was continued with benzene–methanol (9:1). The eluate was evaporated and the residue was distilled with steam. The 2-hydroxy-3-nitrotetralin (IV) separated from the distillate on cooling in the form of bright yellow needles, which were filtered off, washed with petroleum ether, and dried, mp 81-82°C. R_f 0.43

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*The PMR spectrum was taken on a JNM-44-100 spectrometer with a working frequency of 100 MHz. CCl_4 was used as the solvent and hexamethyldisiloxane as the internal standard. The signals of all the protons were appreciably broadened, apparently because of the presence of traces of iron in the sample.

[benzene–methanol (9:1)]. UV spectrum: λ_{max} 288–294, 360 nm; log ε 3.92, 3.54 (in ethanol). IR spectrum, cm^{-1}: 3200 (OH), 1535, 1330 (NO_2) (in paraffin oil). Found, %: C 62.39; H 6.13; N 7.29. Calculated for $C_{10}H_{11}NO_2$, %: C 62.17; H 5.74; N 7.26.

Oxime of 3-Nitro-5,6,7,8-tetrahydro-2-naphthaldehyde (V). The resinous crude oxime obtained in the preceding experiment was treated with 300 ml of water and, with stirring, 70 g of iron sulfate was gradually added and the mixture was boiled for 40 min. After cooling, it was extracted with ether, the ethereal extracts were dried with sodium sulfate, and the solvent was distilled off. The resinous residue crystallized on standing for some days, and it was washed with chloroform and recrystallized from ethanol, mp 169–170°C. R_f 0.46 [benzene–methanol (9:1)]. UV spectrum: λ_{max} 248–250 nm; log ε 4.20 (in ethanol). IR spectrum, cm^{-1}: 3300 (OH); 1670 (C==N); 1530, 1350 (NO_2) (in paraffin oil). Found, %: C 60.05; H 5.72; N 12.80. Calculated for $C_{11}H_{12}N_2O_3$, %: C 59.99; H 5.49; N 12.72.

2-Nitro-3-(β-nitrovinyl)-5,6,7,8-tetrahydronaphthalene (VII). A mixture of 1.8 g of the aldehyde VI, 1.7 ml of nitromethane, 0.67 g of ammonium acetate, and 6.7 ml of glacial acid was boiled in a current of nitrogen for 2 hr. After cooling, the reaction mixture was carefully poured into 40 ml of ice water, and the viscous reaction product that separated out was converted into a solid powder by trituration. It was filtered off, well washed with water, and dried. The yield of crude VII was 2 g. It was dissolved in chloroform, the chloroform solution was washed with saturated sodium bisulfate solution and dried with anhydrous sodium sulfate, concentrated to small volume, and treated with petroleum ether until crystallization began. The precipitate was filtered off, giving 1.3 g (60 %) of compound VII. For analysis, the substance was recrystallized from ethanol, mp 145–146°C. IR spectrum, cm^{-1}: 1640 (C==C), 1550, 1350 (NO_2) (in paraffin oil). Found, %: C 58.05; H 4.83; N 11.67. Calculated for $C_{12}H_{12}N_2O_4$, % : C 58.06; H 4.88; N 11.68.

5,6,7,8-Tetrahydrobenzo[*f*]indole (VIII). With heating to 35°C, 1.3 g of compound VII was dissolved in a mixture of 16 ml of absolute ethanol and 20 ml of glacial acetic acid. With vigorous stirring at 25°C, 4 g of iron powder was added in one portion to the solution, and then the mixture was heated in the water bath at 40–45°C for 30 min, cooled to 20°C, treated with 30 ml of water, and neutralized with dry sodium bicarbonate to pH 7–7.5. Then it was extracted with ether and the ethanol extract was washed with water and dried with anhydrous sodium sulfate. The residue from the distillation of the solvent was dissolved in chloroform and precipitated with petroleum ether. The precipitate was filtered off and was then sublimed in vacuum. This gave 0.2 g (24 %) of substance VIII, mp 63–64°C (from petroleum ether, bp 40–60°C), giving a green color with Ehrlich's reagent, R_f 0.55 (benzene). UV spectrum: λ_{max} 224, 278, 300 nm; log ε 4.50, 3.82, 3.76 (in ethanol). IR spectrum, cm^{-1}: 3420 (N–H) (in paraffin oil). Found, %: N 8.26. Calculated for $C_{12}H_{13}N$, %: N 8.19.

LITERATURE CITED

1. L. B. Shagalov, V. N. Eraksina, K. F. Turchin, and N. N. Suvorov, KhGS [Chemistry of Heterocyclic Compounds], 6, 945 (1970).
2. L. B. Shagalov, V. N. Eraksina, and N. N. Suvorov, KhGS [Chemistry of Heterocyclic Compounds], 6, 951 (1970).
3. E. Goldsmith and H. G. Lindwall, J. Org. Chem., 18, 507 (1953).
4. A. Etienne and A. Staehelin, Bull. Soc. Chim. France, 743 (1954).
5. S. Y. Ambekar, and S. Siddappa, J. Chem. Soc., C, 477 (1966).
6. O. Süs, M. Glos, K. Möller and H. D. Eberhard, Ann., 583, 150 (1953).
7. R. Woodward, F. Bader, H. Bickel, A. Frey and R. Kierstead, Tetrah., 2, 1 (1958).
8. N. N. Suvorov, M. V. Fedotova, O. B. Ogareva, and R. T. Balasheva, ZhOKh, 30, 3118 (1960).
9. G. Schroeter, Ann., 426, 1 (1922).
10. L. Bellamy, Infrared Spectra of Complex Molecules, 2nd Ed., Methuen (1958).
11. J. Beynon, Mass Spectrometry and Its Application to Organic Chemistry, Elsevier (1960).
12. L. A. Cohen, J. W. Daly, N. Kny and B. Witkop, J. Am. Chem. Soc., 82, 2184 (1960).
13. E. R. Ward and T. M. Coulson, J. Chem. Soc., 4545, (1954).