CHEMISTRY OF HETEROCYCLIC N-OXIDES AND RELATED COMPOUNDS

VII.* DEOXIDATION OF PYRIDINE AND QUINOLINE N-OXIDES BY ORGANIC REDUCING AGENTS ON A PALLADIUM CATALYST

A. S. Kurbatova, Yu. V. Kurbatov,
O. S. Otroshchenko, and A. S. Sadykov

UDC 547.828'542.941.7

The corresponding deoxy bases were obtained by hydrogenation of pyridine and quinoline N-oxides by hydrogen transfer from cyclohexene, 1,4-dihydronaphthalene, tetralin, and formic acid on a palladium catalyst.

An important step in the syntheses of substituted pyridine bases by means of N-oxides is elimination of the N-oxide function. Various reductive methods, particularly hydrogenation on palladium and Raney nickel catalysts [2], are used for this purpose.

In the present research we made an attempt to also achieve reduction of this sort by catalytic hydrogen transfer, which differs favorably from catalytic hydrogenation with hydrogen with respect to its experimental simplicity and the good reproducibility of the results [3]. The research was carried out with pyridine N-oxide (I) and quinoline N-oxide (II) and a number of the most active hydrogen donors – cyclohexene, 1,4-dihydronaphthalene, tetralin, and formic acid. The catalyst was palladium-coated asbestos. The reactions were carried out in glacial acetic acid at 93 and 110°C in excess reducing agent.

The hydrogenation of oxides I and II leads to selective reduction of the N-oxide groups. The results of the reduction depend substantially on both the structure of the hydrogen donor and the structure of the hydrogen acceptor (see the experimental section).

The best results in the elimination of the oxide oxygen atom are obtained when cyclohexene is used. This is in agreement with the literature data on the catalytic hydrogenation of other organic compounds by means of cyclohexene [3]. 1,4-Dihydronaphthalene and formic acid display lower reductive capacities. Tetralin was found to be the least active hydrogen donor in the investigated reactions.

The hydrogenation of N-oxide II gives better yields than the hydrogenation of N-oxide I. We also noted the same results in an investigation of homogeneous dehydrogenation reactions of the Hantzsch ester with pyridine and quinoline N-oxides [4]. This is associated with the higher oxidative capacity of quinoline N-oxide ($E_{1/2}$ of II = –1.0692 and $E_{1/2}$ of I = –1.2786 V at pH 3.5 [5]).

The results provide evidence that hydrogenation with hydrogen transfer does not go to completion, regardless of the structures of the N-oxide and the reducing agent, an increase in the temperature, and an increase in the reaction time. This is probably due to poisoning of the catalysts as a result of reaction with the pyridine base.

EXPERIMENTAL

The hydrogenation and isolation of the reaction products were monitored by paper chromatography in a butanol–hydrochloric acid–water system (50 : 7 : 14) (system A) with development by Dragendorf's reagent

---

*See [1] for communication VI.

A. Navoi Samarkand State University. V. I. Lenin Tashkent State University. Translated from Khimiya Geterotsiklicheskikh Soedinenii, No. 7, pp. 920-921, July, 1976. Original article submitted June 3, 1975.

and thin-layer chromatography (TLC) on activity II Al_2O_3 in a benzene–acetone system (3 : 2) (system B) with development by iodine vapors. The reaction products were identified chromatographically and also from the absence of melting-point depressions of mixtures of the picrates of the products with authentic samples.

Hydrogenation of Pyridine N-Oxide (I). A) With cyclohexene. A mixture of 0.5 g (5 mmole) of oxide I [6], 0.5 g (6 mmole) of freshly distilled cyclohexene, 10 ml of glacial acetic acid, and 0.05 g of 30% palladium-coated asbestos [7] was heated, after which the catalyst was removed by filtration and washed, the acetic acid was vacuum evaporated, and the residue was made alkaline with K_2CO_3 and extracted with ether. The extract was dried with Na_2SO_4, after which dry HCl was bubbled through it. The solvent was removed by distillation to give pyridine hydrochloride with R_f 0.35 (system A). The picrate had mp 159-160°. Here and subsequently, the reaction temperature, time, and yield are presented in each case: 94°, 25 h, 45%; 94°, 40 h, 46%; 110°, 25 h, 54%; 20°, 168 h, 40%.

B) With 1,4-dihydronaphthalene. A mixture of 1 g (10 mmole) of oxide I, 1.32 g (10 mmole) of 1,4-dihydronaphthalene [8], 20 ml of glacial acetic acid, and 0.1 g of 30% palladium-coated asbestos was heated, after which the catalyst was removed by filtration, and the solution was diluted with water. The precipitated naphthalene was separated, and the filtrate was treated as described above to give pyridine hydrochloride. The reaction temperatures, times, and yields were as follows: 94°, 40 h, 48%; 110°, 25 h, 58%.

C) With tetralin. The experiment and workup of the reaction mixture were carried out by the method described for hydrogenation with cyclohexene. The reaction temperatures, times, and yields were as follows: 94°, 25 and 40 h, 25%; 110°, 25 h, and 41%.

D) With formic acid. A mixture of 2 g (21 mmole) of oxide I, 20 ml (0.5 mole) of formic acid, and 0.2 g of 30% palladium-coated asbestos was heated, and the carbon dioxide evolved during the reaction was determined in the form of barium carbonate. The pyridine was isolated as described in the case of hydrogenation with cyclohexene. The product was isolated in 44% yield after the mixture was heated at 94° for 25 h.

Hydrogenation of Quinoline N-Oxide (II). A) With cyclohexene. A mixture of 1.47 g (5 mmole) of the dihydrate of oxide II [9], 1 g (12 mmole) of freshly distilled cyclohexene, 20 ml of glacial acetic acid, and 0.1 g of 30% palladium-coated asbestos was heated, after which the catalyst was removed by filtration and washed, and the excess acid was removed by vacuum distillation. The residue was made alkaline and extracted with ether. The extract was dried with Na_2SO_4, the solvent was removed by distillation, and the residue was chromatographed in system B to give quinoline, the picrate of which had mp 198-200° (from ethanol). The reaction temperatures, times, and yields were as follows: 94°, 25 h, 61%; 94°, 40 h, 68%.

B) With 1,4-dihydronaphthalene. A mixture of 1.47 g (5 mmole) of the dihydrate of oxide II, 1.32 g (10 mmole) of 1,4-dihydronaphthalene, 20 ml of glacial acetic acid, and 0.2 g of 30% palladium-coated asbestos was heated, after which the catalyst was removed by filtration, and the filtrate was diluted with water to give 0.45 g (34%) of naphthalene. The filtrate was made alkaline and extracted with ether. The extract was dried with Na_2SO_4, the solvent was removed by distillation, and the residue was chromatographed in system B to give quinoline, the picrate of which had mp 198-200° (from ethanol). The product was obtained in 40% yield after heating the mixture at 94° for 25 h.

C) With tetralin. The experiment was carried out by the method used to hydrogenate oxide II with 1,4-dihydronaphthalene. The reaction temperatures, times, and yields were as follows: 94°, 25 and 40 h, 22%; 110°, 25 h, and 50%.

LITERATURE CITED

1. M. A. Solekhova, Yu. V. Kurbatov, O. S. Otroshchenko, and A. S. Sadykov, Khim. Geterotsikl. Soedin., No. 2, 229 (1976).
2. E. Ochiai, Aromatic Amine Oxides, Amsterdam–London–New York (1967), p. 185.
3. L. M. Jackman, in: Advances in Organic Chemistry, Vol. 2, Interscience Publishers Inc., New York (1960).
4. A. S. Kurbatova, Yu. V. Kurbatov, O. S. Otroshchenko, and A. S. Sadykov, Nauchn. Trudy Samarkandsk. Gos. Univ., 1, No. 167, 26 (1969).
5. E. Ochiai, J. Org. Chem., 18, 534 (1953).
6. K. Thomas and D. Jerchel, Angew. Chem., 70, 719 (1958).
7. N. D. Zelinskii, Selected Works [in Russian], Vol. 2, Moscow (1941), p. 227.
8. E. Bamberger, Ann., 288, 75 (1895).
9. M. Ali-Zade, Uch. Zap. Leninabadsk. Gos. Ped. Instit., 3, 111 (1956).