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FORMATION OF CYCLIC NITRONE FROM NITRITE OF FUSED FIVE-MEMBERED RING ALCOHOL BY PHOTOCHEMICAL REARRANGEMENT (1)

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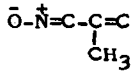
The photochemical transformation of nitrite esters of fused 5-membered ring alcohols usually leads to the formation of cyclic hydroxamic acids (2).

We wish to report that irradiation of the nitrite Ib of a fused cyclopentanol induces extensive reorganization of the molecule and leads to the formation of a novel cyclic nitrone II with an excellent yield.

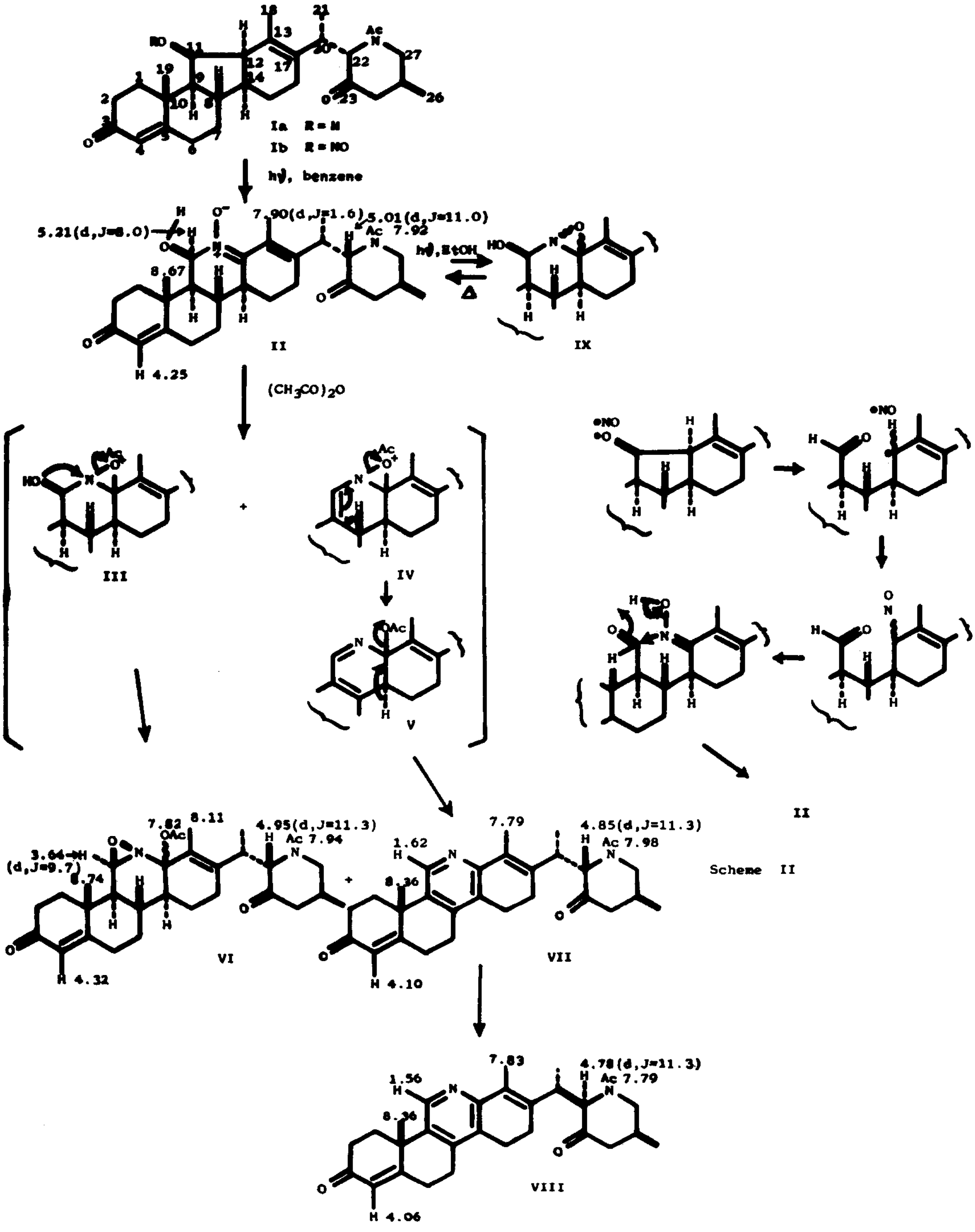
The nitrite Ib, m.p. 179-182°, was prepared from jervine via 7 steps (3). Photolysis of Ib in toluene for 3 hr as described in the previous paper (4) produced II as virtually the sole product (59%). Structure II of the photoproduct was deduced on the basis of the spectroscopic, chemical and photochemical evidence and the consideration of the mode of the formation.

The molecular formula of II was determined as $C_{29}H_{40}O_5N_2$ from the elemental analysis and the mass spectrum (M^+ 496). The assignments of the signals of the nmr (100 Mc) of II are shown as the figures on the formula II. A notable feature in the lower field of the spectrum is the appearance of a doublet at τ5.21 (J=8.0) which is lacking in Ia and is assignable to an adjacent αH to the N-oxide group as shown. A signal due to 18-methyl is considerably deshielded when compared with the corresponding signal of the precursor Ia. Ir (Nujol) shows a broad OH absorption of around 3300, 6-membered ring ketone at 1705, Δ^4-3-one at 1668, N-Ac at 1621 and $\overset{+}{N}=C$ at 1565 cm^{-1}. Uv shows absorption maxima due to Δ^4-3-one chromophore at 238 mμ (ε, 16,500) and also due to  $\bar{O}-\overset{+}{N}=C-\underset{CH_3}{C}=C$ at 289 mμ (ε, 10,700).

Brief treatment of II with acetic anhydride yields two products, VI and VII. An amorphous substance VI shows an absorption maximum at 238 mμ (ε, 23,600) in its uv and the absorption at longer wave length in II disappears. Ir shows the bands at 1654 (N-Ac), 1668 (Δ^4-3-one) and 1730 cm^{-1} (O-Ac) but no absorption due to OH and N=C. Based on the structure II for the photoproduct and the spectroscopic evidence above, the compound can be formulated as an oxaziridine (VI) (5). Migration of the acyloxy group during N-oxide acylation has been known in N-oxide chemistry (6,7,8).

The compound VII (M^+ 460) (m.p. 225-229°) shows the nmr values as pointed out in the scheme and the distinct feature here is the appearance of one proton singlet at τ1.62 which corresponds to the α-hydrogen of pyridine nucleus and the disappearance of a doublet at τ5.21 in II. Its ir shows no absorption in OH region, 1708 (6-membered ring ketone), 1679 (Δ^4-3-one), 1629 (N-Ac) and 1570 cm^{-1} (N=C). In the uv an absorptions at 225 mμ (ε, 25,000) and 298 mμ (ε, 8,700) and an absorption due to Δ^4-3-one appears only as a shoulder at 239 mμ (ε, 20,800). These spectroscopic results are in accord with the structure VII arising probably from the initial loss of the elements of water from II followed by acyloxy migration and elimination of the elements of acetic acid as depicted (IV, V) (8). VII readily isomerizes to the compound VIII, m.p. 269.5-271°, λ_{max}^{Nujol} 1707 (6-membered ring ketone), 1661 (Δ^4-3-one), 1643 (N-Ac) and 1578 cm^{-1} (N=C) either on a thin layer of silica gel or with 2.5% methanolic KOH. Uv of VIII is nearly identical with that of VII and the only significant difference in the nmr of VIII with that of VII is the downfield shift of the signal due to the N-acetyl protons. We propose the structure VIII on the basis of the spectroscopic data above. The correctness of the structure II for the photoproduct is confirmed by the observation that II in ethanol is converted on irradiation through pyrex with a high pressure Hg arc lamp into an extremely unstable compound IX from which II regenerates thermally. This transformation is readily explicable by assuming the formation of an oxaziridine (IX) as shown (9).

A probable sequence which leads to the photoproduct would be (1) homolysis of the ONO group of nitrite followed by homolytic rupture of the C-C single bond between C_{11} and C_{12}; (2) the formation of C-nitroso-aldehyde; (3) isomerization



Scheme II

Scheme I

to an oximino-aldehyde and, (4) photochemical cyclization (10) to afford the nitrone, as shown in the scheme II (11).

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References and footnotes

(1) Photoinduced Transformations. XII, paper XI, H. Suginome, H. Ono and T. Masamune, Tetrahedron Letters, in press.

(2) C. H. Robinson, O. Gnoj, A. Mitchell, R. Wayne, E. Townley, P. Kabasakalian, E. P. Oliveto and D. H. R. Barton, J. Amer. Chem. Soc., 83, 1711 (1961); C. H. Robinson, O. Gnoj, A. Mitchell, E. P. Oliveto and D. H. R. Barton, Tetrahedron, 21, 743 (1965); P. Kabasakalian and E. R. Townley, J. Org. Chem., 27, 3562 (1962); M. Nakazaki and K. Naemura, Bull. Chem. Soc. Japan, 37, 532 (1964); J. D. White and D. N. Gupta, J. Amer. Chem. Soc., 90, 6171 (1968).

(3) Synthetic details will be described in the full paper.

(4) e.g., H. Suginome, M. Murakami and T. Masamune, Chem. Comm., 343 (1966); Bull. Chem. Soc. Japan, 41, 468 (1968).

(5) The compound VI is unstable to acids but stable to alkaline conditions. Unusual stability under alkaline treatment has been observed in oxaziridine bearing tri-substituted carbon on nitrogen. E. Schmitz in "Advances in Heterocyclic Chemistry," Vol. 2, A. R. Katritzky, Ed., Academic Press, New York, N. Y., 1963, p. 83. Moreover, in agreement with oxaziridine structure, the compound in acetic acid-2-propanol rapidly oxidizes iodide ion to iodine.

(6) M. Katada, J. Pharm. Soc. Japan, 67, 51 (1947); V. Boekelheide and W. J. Linn, J. Amer. Chem. Soc., 76, 1286 (1954); for review see E. Ochiai "Aromatic Amine Oxides," Elsevier, Amsterdam, 1967, p. 290.

(7) M. Lamchen in "Mechanisms of Molecular Migrations," Vol. 1, B. S. Thyagarajan, Ed., Interscience Publishers, New York, N. Y., 1968, p. 1.

(8) Suggested rationalizations involving oxaziridines as intermediates (III, IV and V) are only tentative although this seems most plausible in view of a recent work (7). An alternative would be one involving an intermolecular ionic process; e.g., S. Oae and S. Kozuka, Tetrahedron, 20, 2691 (1964).

(9) A number of examples on photochemical generation of thermally unstable oxaziridines from the corresponding nitrone are known; e.g., M. J. Kamlet and L. A. Kaplan, J. Org. Chem., 22, 1263 (1957). J. S. Splitter and M. Calvin, J. Org. Chem., 23, 651 (1958). R. Bonnett, V. M. Clark and Sir Alexander Todd, J. Chem. Soc., 2102 (1959). L. S. Kaminsky and M. Lamchen, J. Chem. Soc., (C), 2295 (1966), J. B. Bapat and D. St. C. Black, Chem. Comm., 73 (1967). For a recent review see reference (7).

(10) The process may not necessarily be cyclic as depicted. Alternatively the transfer of protons can be intermolecular.

(11) Satisfactory elemental analyses (C, H and N) were secured on all new compounds described.