

RING EXPANSION OF NORTRICYCLANONE

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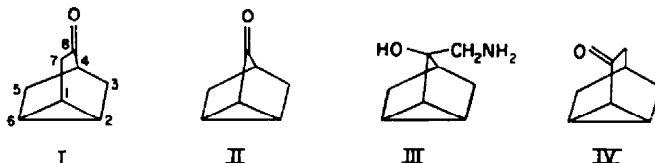
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Abstract—Ring expansion of nortricyclanone by the Tiffeneau–Demjanow procedure gave a mixture of two ketones in which tricyclo(2,2,2,0^{3,6})octan-8-one (I) largely predominated, the minor product being tricyclo(2,2,2,0^{3,6})octan-7-one (IV). A possible rationalization for the course of the ring expansion is discussed.

As a possible source of the tricyclic ketone (I), we have investigated methods for the ring expansion of nortricyclanone (II).

Preliminary experiments on the reaction of diazomethane with nortricyclanone gave unpromising results. No reaction occurred between diazomethane and nortricyclanone alone, while in the presence of boron trifluoride-etherate¹ only low and very variable yields of a new ketone were obtained. The latter was later shown to be gas chromatographically identical with a sample of ketone (I) obtained below.² We turned our attention, therefore, to the Tiffeneau–Demjanow procedure.³



Nortriacyclanone cyanohydrin was acetylated with acetic anhydride–pyridine and the resulting acetate reduced to the hydroxyamine (III) with lithium aluminium hydride.⁴ Deamination of III using sodium nitrite in acetic acid gave a mixture of two ketones comprising 90 and 10% of the total product. The minor ketone proved to be identical with the ketone (IV) derived by Moore *et al.*⁵ from the adduct of norbornadiene and dibromocarbene. The major ketone was assigned the isomeric structure (I) on the basis of: (i) ν_{\max} (in CS_2) at 1730 cm^{-1} (unconjugated carbonyl group in a slightly strained six-membered ring) (ii) low end absorption in the UV rising to ϵ , 2000 at $190\text{ m}\mu$, cf., $\lambda_{\max}^{\text{heptane}}$ $192\text{ m}\mu$ (ϵ , 7090) for ketone (IV),⁵ (iii) the NMR spectrum which demonstrated the absence of vinyl protons and which possessed a doublet at 7.6τ attributable to the two hydrogens on C-7, split ($J = 3\text{ c/s}$) by the

¹ H. O. House, E. J. Grubbs and W. F. Gannon, *J. Amer. Chem. Soc.* **82**, 4099 (1960).

² Professor R. R. Sauer (Rutgers) has investigated this reaction and he also finds the ketone (I) to be the only product. We thank Prof. Sauer for informing us of his results prior to publication.

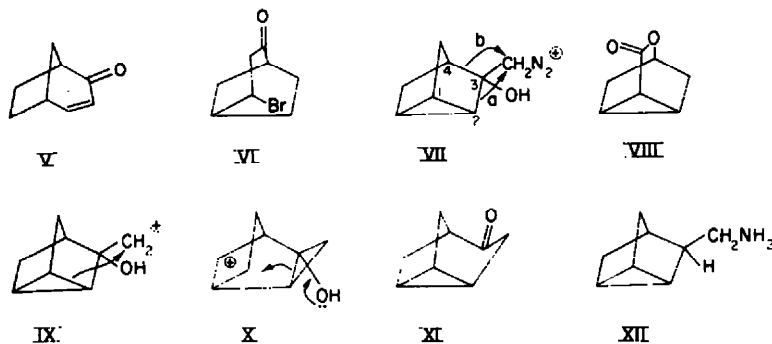
³ P. A. S. Smith and D. R. Baer, *Organic Reactions* **11**, 157 (1960).

⁴ The cyanohydrin was recovered after attempted hydrogenation over Pt in acetic acid while direct reduction with LiAlH_4 gave an unknown solid material which was not further investigated. The present route, which is successful presumably because the cyano group is reduced before the acetyl group, is based on a procedure of J. D. Roberts and W. F. Gorham, *J. Amer. Chem. Soc.* **74**, 2278 (1952).

⁵ W. R. Moore, W. R. Moser and J. E. LaPrade, *J. Org. Chem.* **28**, 2200 (1963). We are indebted to Prof. Moore for copies of the IR and NMR spectra of his ketone.

adjacent hydrogen on C-1. Confirmatory chemical evidence for the tricyclic structure (I) was provided by (i) lithium aluminium hydride reduction which gave a single alcohol, in agreement with a symmetrical environment for the carbonyl group, and (ii) treatment with hydrogen bromide in acetic acid which gave the unsaturated ketone (V)⁶ in moderate yield. The latter reaction presumably involves the β -bromo-ketone (VI) as an unstable intermediate.

The deamination of the hydroxyamine (III) involves, therefore, preferred migration of C-2 (path a) rather than C-4 (path b) in formula (VII). The predominance of path a is perhaps surprising on intuitive grounds since migration of the more electronegative cyclopropyl carbon (C-2) might be expected to be less favourable than that of C-4.⁷ Some support for this expectation is given by the Baeyer-Villiger oxidation of nortricyclanone which is reported⁸ to lead exclusively to the lactone (VIII), i.e., by migration of C-4 to electron deficient oxygen.⁹ For the related reaction of diazomethane with ketones¹ it is found in the case of $\alpha\beta$ -unsaturated ketones, that migration of unsaturated carbon is the predominant pathway. This result is usually ascribed to overlap of the π -orbital of the double bond with the developing vacant orbital at the migration origin. In the present case a possible rationalization for the transformation of III into I, involving conjugative electron release from the cyclopropane ring, is indicated by the sequence, IX \rightarrow X \rightarrow XI \equiv I, depicted in terms of classical ions for clarity. Recent results on the deamination of the related amine (XII), which may be interpreted in terms of a similar electrophilic attack of the exocyclic carbonium ion centre on the cyclopropane ring,¹⁰ provide some support for this scheme.



EXPERIMENTAL

A Pye Argon Chromatograph equipped with a column of polyethyleneglycol adipate was used for gas chromatography.

Nortricyclanone cyanohydrin acetate. Potassium cyanide (60 g) was added during 20 min to a stirred solution of nortricyclanone (5 g) in ethanol (170 ml) containing glacial acetic acid (65 ml) at 0°. After 30 min at 0° followed by 2 hr at 20° the mixture was poured into water and the product extracted

⁶ H. L. Goering, R. W. Greiner and M. F. Sloan, *J. Amer. Chem. Soc.* **83**, 1391 (1961).

⁷ The work of G. E. Cartier and S. C. Bunce, *J. Amer. Chem. Soc.* **85**, 932 (1963), on the deamination of 2-cyclopropyl ethylamine-1¹⁴C shows, however, that there is no great barrier to such a migration of a cyclopropyl group.

⁸ R. R. Sauer, *Tetrahedron Letters* No. 22, 1015 (1962).

⁹ Special factors may, however, be operative in this case since oxidation of methyl cyclopropyl ketone with peroxytrifluoroacetic acid gives cyclopropyl acetate, W. D. Emmons and G. B. Lucas, *J. Amer. Chem. Soc.* **77**, 2287 (1955).

¹⁰ R. R. Sauer and J. A. Beisler, *Tetrahedron Letters* No. 32, 2181 (1964).

with ether. Evaporation at 20° (red. press.) gave the cyanohydrin as a yellow viscous liquid (7.6 g) which showed ν_{\max} (liquid film) 3400 (OH) and 2240 cm^{-1} ($\text{C}\equiv\text{N}$). Acetylation, using acetic anhydride (10 g)–pyridine (8 g) at 20° for 16 hr, followed by working up in the usual way gave a dark liquid (7.4 g) which was homogeneous to gas chromatography. Distillation gave the *cyanohydrin acetate* as a colourless oil (6.3 g, 77%), b.p. 82–83°/0.5 mm, ν_{\max} (liquid film) 2240 ($\text{C}\equiv\text{N}$) 1755 and 1240 cm^{-1} (—OAc). (Found: C, 68.35; H, 6.4; N, 7.75. $\text{C}_{10}\text{H}_{11}\text{N}_2\text{O}$ requires: C, 67.8; H, 6.25; N, 7.9%.)

3-(Aminomethyl)nortricyclan-3-ol. The cyanohydrin acetate (9.8 g) was heated under reflux with LiAlH_4 (6 g) in ether for 1 hr and the excess reagent destroyed by addition of a slurry of Na_2SO_4 in water. Filtration and evaporation followed by crystallization of the solid residue from ethyl acetate gave the *hydroxyamine* as white rhombs (4.8 g, 63%) m.p. 94.5–95.5°. The analytical sample had m.p. 95.5–96.5°. (Found: C, 69.0; H, 9.6; N, 10.0. $\text{C}_8\text{H}_{13}\text{NO}$ requires: C, 69.05; H, 9.4; N, 10.05%.)

Deamination of the hydroxyamine. Sodium nitrite (2.3 g) in water (7 ml) was added during 15 min to a stirred solution of the hydroxyamine (3.7 g) in water (55 ml) containing acetic acid (2.0 ml) at 5°. The mixture was maintained at 5° during 30 min, at 20° during 30 min, and finally heated on the steam bath during 1 hr. After dilution with water, the product was isolated with ether as a yellow liquid (3.1 g) which contained two components (90 and 10%) by gas chromatography. Chromatography on silica gel (70 g) followed elution with light petroleum–ether (9:1 to 7:3) gave *tricyclo(2,2,2,0^{2,9})octan-8-one* (2.7 g, 83%) b.p. ca. 90°/16 mm, ν_{\max} (in CS_2) 3060, 2970, 2930, 2860, 1730, 1325, 1270, 1235, 1145, 1105, 1045, 975, 820, 775, 770 cm^{-1} . The ketone was characterized as the 2,4-dinitrophenylhydrazone, needles from ethanol, m.p. 194.5–195°. (Found: C, 55.3; H, 4.85; N, 18.55. $\text{C}_{14}\text{H}_{14}\text{O}_4\text{N}_4$ requires: C, 55.6; H, 4.65; N, 18.55%). Further elution of the column with ether gave *tricyclo(2,2,2,0^{2,9})octan-7-one* (0.3 g, 9%) identified by comparison with an authentic specimen⁸ (IR and NMR spectra, mixed gas chromatogram and mixed m.p. of the 2,4-dinitrophenylhydrazones).

Tricyclo(2,2,2,0^{2,9})octan-8-ol. The ketone (I, 310 mg) was reduced with LiAlH_4 in refluxing ether giving the *alcohol* as a white waxy solid (310 mg) which gave a single peak on gas chromatography. After sublimation it had m.p. 123.5–124.5°. (Found: C, 77.25; H, 9.65. $\text{C}_{13}\text{H}_{18}\text{O}$ requires: C, 77.35; H, 9.75%.)

Ring expansion of nortricyclanone with diazomethane. Dry ethereal diazomethane (from nitrosomethylurea, 400 mg) was added to nortricyclanone (105 mg) and BF_3 -etherate (0.13 ml) at 0°. The ether was washed with water, dried and evaporated giving a yellow oil (71 mg). Gas chromatography showed the presence of starting material (60%) and another compound (40%) with a retention time identical with that of ketone (I) obtained above.

This reaction could not be consistently reproduced and starting material was frequently recovered unchanged.

Treatment of the ketone (I) with hydrogen bromide in acetic acid. The ketone (208 mg) in acetic acid containing HBr (25% 1 ml) was maintained at 40° for 4 hr. After dilution with water the product was isolated with ether as a yellow oil. Gas chromatography showed only one component. This was inseparable from an authentic specimen of the ketone (V). The UV spectrum, λ_{\max} (in EtOH) 227 $m\mu$ (ϵ 1670), indicated the presence of 18% of ketone (V). Goering *et al.*⁸ give λ_{\max} (in EtOH) 227 $m\mu$ (ϵ , 9550) for this compound. The remaining material was considered to be bromoketones which did not chromatograph under the conditions used.

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