

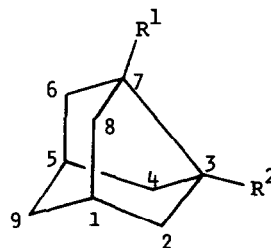
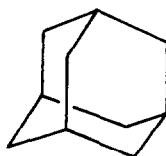
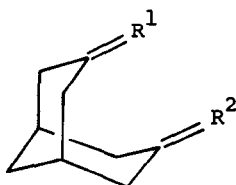
ON THE TRANSANNULAR CYCLIZATION OF 3,7-DIFUNCTIONALIZED
BICYCLO[3.3.1]NONANES: REVISION OF THE LITERATURE

Takefumi Momose* and Osamu Muraoka

Faculty of Pharmaceutical Sciences, Osaka University, Osaka, Japan

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In 1965, Eakin, Martin, and Parker¹ described the Wolff-Kishner reduction of 7-methylenebicyclo[3.3.1]nonan-3-one (1). Instead of the normally reduced olefin, 3-methylenebicyclo[3.3.1]nonane (2), these authors obtained adamantane (3) as the sole product through a transannular cyclization.² On the other hand, Stetter and Tacke³ reported the Wolff-Kishner reduction of bicyclo[3.3.1]nonane-3,7-dione (4) to give the normally reduced parent hydrocarbon (5), instead of a cyclized product (6), in contrast with the results of related systems described by Agosta^{4a} and by Föhlisch et al.^{4b} The latter results prompted us to reexamine the Wolff-Kishner reduction of 1 in pursuit of the normally reduced olefin (2), which was a key substance in our recent study for developing synthetic routes to bicyclo[3.3.1]nonan-3-one.⁵ The result we now wish to report is completely discrepant from that reported by Eakin et al.

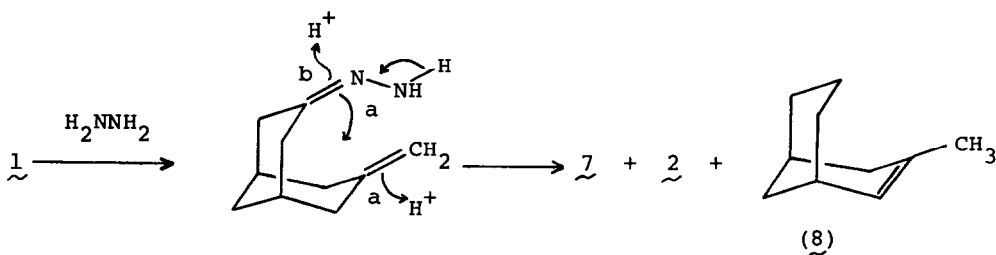


- (1): $R^1=O, R^2=CH_2$
 (2): $R^1=H_2, R^2=CH_2$
 (4): $R^1=O, R^2=O$
 (5): $R^1=H_2, R^2=H_2$
 (11): $R^1=NNHCONH_2, R^2=CH_2$
 (13): $R^1=R^2=NNHCONH_2$

(3)

- (6): $R^1=H, R^2=OH$
 (7): $R^1=H, R^2=CH_3$
 (9): $R^1=CH_3, R^2=OH$
 (10): $R^1=CH_3, R^2=Cl$
 (12): $R^1=H, R^2=H$

Treatment of 1 with 85%, 95% or 100% hydrazine hydrate followed by alkaline cleavage at 200° gave a waxy solid in 65-76% yield. Glc analysis of the crude products showed three peaks with the ratio of 25-35:7-10:1 corresponding to 3-methyltricyclo[3.3.1.0^{3,7}]nonane (3-methylnoradamantane) (7), 3-methylenebicyclo[3.3.1]nonane (2), and 3-methylbicyclo[3.3.1]non-2-ene (8), respectively. No detectable amounts of adamantane were obtained in spite of repeated experiments. The crude mixture was chromatographed effectively on silica gel impregnated by silver nitrate with pentane as eluent. The structure of 7 was assigned on the basis of its physical properties [mp. 109-110° (totally submerged sealed capillary). IR (CCl₄): 2945, 2865, 1456, 1332, 1305, 1131, 1098, 1079, 669. ¹H-NMR (CCl₄): δ 1.15 (3H, s, -CH₃). ¹³C-NMR (CCl₄): δ 51.05 (C₂, C₄), 44.41, 44.14 (C₆, C₈), 37.88 (C₁, C₅), 34.86 (C₉), 25.58 (-CH₃). Mass: m/e 136 (M⁺, 40% at 26 eV)]. Final structural confirmation was performed by direct comparison of its IR, ¹H-NMR, and ¹³C-NMR spectra with those of an authentic sample prepared from 7-methyltricyclo[3.3.1.0^{3,7}]nonan-3-ol (9)^{1,6} by chlorination with thionyl chloride and subsequent reductive dehalogenation of the resulting halide (10) with lithium/tert-butyl alcohol in tetrahydrofuran. The formation of 7 would be derived from the transannular exo-protonation in the first step of its reduction (route a). This cyclization competes with a normal reduction to the olefin (2) (route b). Structures of the two minor products, 2 and 8, are respectively supported by comparison of their spectral properties with those published.⁷



Treatment of the corresponding semicarbazone (11) with 15% potassium hydroxide in diethylene glycol (200°, 2 hr) gave the same members of products as those obtained by the Wolff-Kishner reduction of 1, but with different product distribution. The composition of the products was (7): 70%, (2): 17%, (8): 13%.

In consideration of these results and of the ease of transannular cyclization upon the Wolff-Kishner reduction of some cyclic 1,5-diketones,⁴ it was difficult to rule out some possibility of the formation of tricyclo[3.3.1.0^{3,7}]nonan-3-ol (6) in the Wolff-Kishner reduction of bicyclo[3.3.1]nonane-3,7-dione (4).

The Wolff-Kishner reduction of 4 gave a highly sublimable solid in 56% yield. Glc analysis of the crude products showed two peaks with the ratio of ca. 25:1. The main component was identified as its parent hydrocarbon, bicyclo[3.3.1]nonane (5), as was reported by Stetter and Tacke.³ The structure of the minor one was assigned as tricyclo[3.3.1.0^{3,7}]nonane (12)⁸ by comparison of its retention time (3.6 min., 60°) on glc⁹ and fragment pattern of the GC-Mass spectrum¹⁰ [m/e: 122 (M⁺, 18% at 26 eV) and some eminent fragment peaks at 93, 81, 80 (base peak), 79, 78, 77, 67, 66, 65, 53, 41, 39] with those of an authentic sample, obtained from tricyclo[3.3.1.0^{3,7}]nonan-3-ol (6)¹¹ by the same procedure as that for 7 from 9. The alkaline cleavage of bissemicarbazone (13) also gave the same components with slightly different proportions of the products (ca. 20:1). The formation of 6 was not observed in these reductions.

Consequently, the transannular bridge formation of intramolecularly faced functionalities upon the Wolff-Kishner reduction was revealed as a general feature. The origin of the different feature of product formation between 4 and its analogous systems will be the subject of further investigation.

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10. The authors are grateful to Dr. H.K. Sasaki (Osaka City Institute of Public Health and Environmental Sciences) for his help in the GC-Mass measurements.
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