Deamination of 2-*exo*-Hydroxy-3-*exo*-aminobornane. An Endo–Endo Hydride Shift to a Secondary Carbonium Ion[1]

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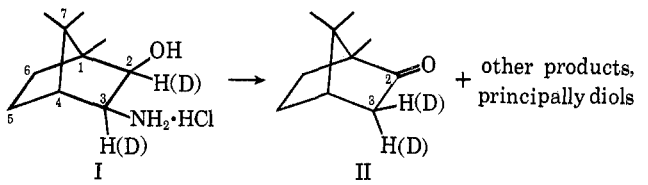
Vicinal 2,3-hydride migrations in the norbornyl series have been reported to proceed *via* an exo–exo pathway.[2,3] Only recently the first vicinal 2,3 endo–endo hydride migration in the bornyl series was observed in this laboratory.[4] We would like now to report what appears to be the first case of an endo–endo hydride shift to a secondary carbonium ion.

The reaction of the hydrochloride (I) of 2-*exo*-hydroxy-3-*exo*-aminobornane with nitrous acid according to the method of Wildman and Saunders[5] afforded products containing camphor (II) (20%), diols (48%), and



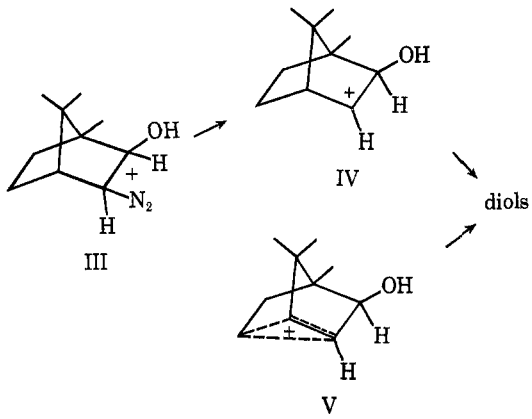
I II

a mixture of unknowns. The diols did not appear to be homogeneous. The unseparated diol mixture was oxidized by the CrO_3–pyridine complex to the respective ketones which showed carbonyl absorptions at 1779[6] and 1742 cm^{-1}. The camphor produced by deamination was shown to be identical with a commercial sample, including its mass spectral fragmentation pattern.[7] A mixture melting point of 2,4-dinitrophenylhydrazones showed no depression.

The hydrochloride I was prepared from 3-oximino camphor[8] by reduction with lithium aluminum hydride. The exo–cis structure of the salt was established by its nmr spectrum. Two sharp doublets, centered at 3.83 (J = 7.5 cps) and 3.33 ppm (J = 7.5 cps), are assigned respectively to the endo protons at C_3 and C_2.

The endo–endo 2,3 hydride shift was confirmed by subjecting 2-*exo*-hydroxy-3-*exo*-aminobornane-2,3-d_2 hydrochloride to the same rearrangement conditions. The nmr trace of the deuterated camphor was identical with the protonated form except for signals for 3-exo and 3-endo protons centered at 2.39 and 1.79 ppm, respectively. A comparison of the mass spectral data with those of the protonated camphor confirmed that the deuterated camphor contained more than 95% of the deuterium at the 3 position.[7] *We believe that these observations represent the first case of an endo–endo hydride migration to a secondary carbonium ion.*[9]

In the deamination of I the diazonium ion III gives directly the "hot" classical ion[9,10] IV from which camphor



is produced *via* an endo–endo hydride shift. The diazonium ion may also yield the bridged ion V by assisted ionization. Since the yield of camphor is 20%, it can be concluded that at least this percentage of classical ion IV is formed This value is close to that reported by Hückel and Nerdel in the deamination of 2-*endo*-aminobornane.[11] Both ions IV and V may yield diols (48%).

Finally, the possibility of a concerted mechanism should be considered. Decomposition of the diazonium ion III to camphor by a concerted 2,3-endo hydride shift seems unlikely since (a) the leaving group and migrating group are at an angle of 120°, and (b) the rates of Wagner–Meerwein rearrangements and of 6,2-hydride shifts are fast compared to a 3,2-hydride shift.[11,12]

Our results are inconsistent with a bridged carbonium ion intermediate which is reported to prevent endo–endo migrations.[3] These results can, however, be interpreted in terms of open, classical intermediates.

Experimental Section[13]

3-Oximinocamphor.—A mixture of 33.2 g (0.20 mol) of camphorquinone and 13.9 g (0.20 mol) of hydroxylamine hydrochloride was dissolved in 250 ml of methanol. To this solution, 21.6 g (0.22 mol) of potassium acetate was added. The stirred mix-

(1) (a) Taken from a dissertation submitted by W.-C. Hsieh to the Graduate School of Duke University in partial fulfillment of the requirements for the Ph.D. degree, 1970. (b) The support of this research by a grant (CA-4298) from the National Cancer Institute of the National Institutes of Health, U. S. Public Health Service, is acknowledged with gratitude.

(2) D. C. Kleinfelter and P. v. R. Schleyer, *J. Amer. Chem. Soc.*, **83**, 2329 (1961); C. J. Collins, Z. K. Cheema, R. G. Werth, and B. M. Benjamin, *ibid.*, **86**, 4913 (1964); B. M. Benjamin and C. J. Collins, *ibid.*, **88**, 1556 (1966); D. C. Kleinfelter and T. E. Dye, *ibid.*, **88**, 3174 (1966).

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(13) Melting points and boiling points are uncorrected. Analyses are by Galbraith Laboratories, Knoxville, Tenn., or M-H-W Laboratories, Garden City, Mich. Analytical glpc analyses were performed on a Varian Aerograph Series 1200 instrument; preparative glpc analyses were performed on an Aerograph Model A-700 autoprep. Nmr spectra were recorded on a Varian T-60 spectrometer. Mass spectra were recorded on a Bendix time-of-flight spectrometer.

ture was heated under reflux for 3 hr. Most of the methanol was removed (about 200 ml) by distillation and 150 ml of ethyl acetate was added. Potassium chloride was removed (about 15 g) by filtration and was washed several times with ethyl acetate. The combined ethyl acetate solutions were neutralized with saturated $NaHCO_3$ solution and were dried over anhydrous magnesium sulfate. Removal of the solvent at reduced pressure yielded the pale yellow ketoxime. A single recrystallization from ligroin afforded 28.3 g (78%) of 3-oximinocamphor, mp 120–123° (reported[14] 131–133°). The product was used without further purification.

2-*exo*-Hydroxy-3-*exo*-aminobornane.—In a 2-l. three-necked flask, equipped with a condenser, a mechanical stirrer, and a dropping funnel, were placed 400 ml of anhydrous ethyl ether (dried over sodium wire) and 21.4 g (0.56 mol) of $LiAlH_4$. After the mixture had been stirred for 15 min, 33.9 g (0.19 mol) of 3-oximinocamphor in 400 ml of anhydrous ethyl ether was added from a dropping funnel at a rate such as to maintain reflux. After being heated under reflux overnight, the mixture was cooled to room temperature and excess $LiAlH_4$ was then destroyed by addition of wet ether, followed by cold water. A white curdy mass of aluminum hydroxide was removed by filtration and was washed several times with ether. The combined ether solutions were dried over anhydrous magnesium sulfate. When the solvent was removed, the residue was distilled under reduced pressure. The product which distilled at 65.1–65.8° (0.5 mm) solidified and was recrystallized from cold heptane. The yield was 23.6 g (75%), mp 213–214°.

Anal. Calcd for $C_{10}H_{19}NO$: C, 70.96; H, 11.32; N, 8.28. Found: C, 71.12; H, 11.47; N, 8.29.

A benzenesulfonate derivative was prepared, mp 147–149°.

Anal. Calcd for $C_{16}H_{23}NO_3S$: C, 62.13; H, 7.50; N, 10.34. Found: C, 62.33; H, 7.60; N, 10.65.

2-*exo*-Hydroxy-3-*exo*-aminobornane Hydrochloride (I).—Dry hydrogen chloride gas was bubbled through a vigorously stirred solution of 30 g of 2-hydroxy-3-aminobornane in 1 l. of dry ethyl ether. When the ether solution was acidic to litmus paper, addition of hydrogen chloride gas was halted and the white precipitate was collected. The yield was 33 g (90%). Further recrystallization from ether and methanol mixture afforded 27 g (74%) of hydrochloride salt, dec >175°.

Anal. Calcd for $C_{10}H_{20}NOCl$: C, 58.38; H, 9.79; N, 6.80; Cl, 17.23. Found: C, 58.15; H, 9.70; N, 6.93; Cl, 17.42.

When the hydrochloride salt was treated with 20% NaOH, free amine was collected as white crystals, mp 213–214°, which had the same nmr and ir as the amino alcohol from which the salt had been prepared.

2-*exo*-Hydroxy-3-*exo*-aminobornane-2,3-*d*.—The procedure described above for the preparation of the amino alcohol was followed except for the use of $LiAlD_4$. The deuterated hydrochloride salt (3.9 g) was isolated from 4.5 g of 3-oximinocamphor. The nmr spectrum of the deuterated salt in D_2O was identical with the protonated form except for the absence of signals at 3.33 and 3.83 ppm. When subjected to sublimation at 40° (0.5 mm), deuterated amino alcohol with mp 211–213° was obtained. The mass spectrum of the deuterated amino alcohol confirmed two deuterium atoms in the molecule.

Deamination of 2-*exo*-Hydroxy-3-*exo*-aminobornane Hydrochloride (I) in Water.—The hydrochloride salt (4.2 g) in 42 ml of H_2O was stirred and cooled in an ice–water bath. A solution of 3.1 g of $NaNO_2$ in 21 ml of H_2O was added. Eight drops of concentrated H_2SO_4 was added to induce the deamination reaction. The mixture was stirred for 4 hr and was stored overnight in a refrigerator. The mixture was poured into water and then was extracted with ethyl ether. Camphor was isolated by preparative gc using a 10-ft 20% Carbowax 20M column at 150°, mp 177–178° (reported[14] 178.8°). A 2,4-dinitrophenylhydrazone derivative was prepared, mp 167.5–168° (reported[15] 164°).

Deamination of 2-*exo*-Hydroxy-3-*exo*-aminobornane-2,3-d_2 Hydrochloride.—The procedure was the same as that described above. The nmr spectrum of deuterated camphor was identical with protonated camphor except for the signals for 3-exo and 3-endo protons which were absent. The mass spectrum showed two deuterium atoms in the molecule.

Registry No.—I, 25050-53-7; I benzenesulfonate, 30248-03-4; I HCl, 26126-95-4; II, 76-22-2.

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Synthesis of 1-*N*-Glycosyl-1,2,3-triazoles from Glycosyl Azides and Substituted Acetylenes

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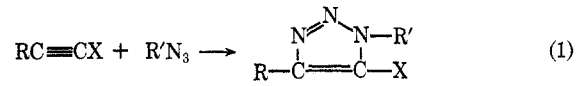
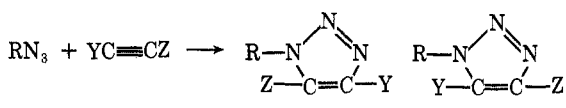
The additions of simple alkyl and aryl azides to various substituted acetylenes are known to produce the corresponding triazoles[1-4] (eq 1). As an extension



(1)

of this work, we investigated the addition of several fully acetylated β-D-glycosyl azides to acetylenes substituted by *N*,*N*-dialkylamino, ethoxy, and ethylthio groups. This study has led to some interesting observations. In particular, the additions of hepta-*O*-acetyl-β-D-maltosyl and hepta-*O*-acetyl-β-D-cellobiosyl azides to ethoxyacetylene were quite significant because each of them yielded both the possible isomeric triazoles. Previously reported additions of azides to ethoxyacetylene afforded only one of the two triazoles.

Addition of Glycosyl Azides 1a–d to Substituted Acetylenes 2a–d. (1) Addition to Ynamines 2a and



1a–d 2a–d 3a–k 4a–c

1a, R = D-glucosyl
b, R = D-galactosyl
c, R = maltosyl
d, R = cellobiosyl

2a, Y = CH_3; Z = $N(Et)_2$
b, Y = Ph; Z = $N(Me)_2$
c, Y = OEt; Z = H
d, Y = SEt; Z = Ph

3a, Y = CH_3; Z = $N(Et)_2$; R = D-glucosyl
b, Y = CH_3; Z = $N(Et)_2$; R = D-galactosyl
c, Y = CH_3; Z = $N(Et)_2$; R = maltosyl
d, Y = CH_3; Z = $N(Et)_2$; R = cellobiosyl
e, Y = Ph; Z = $N(Me)_2$; R = D-glucosyl
f, Y = Ph; Z = $N(Me)_2$; R = D-galactosyl
g, Y = Ph; Z = $N(Me)_2$; R = maltosyl
h, Y = H; Z = OEt; R = D-glucosyl
i, Y = H; Z = OEt; R = D-galactosyl
j, Y = H; Z = OEt; R = cellobiosyl
k, Y = H; Z = OEt; R = maltosyl

4a, Y = H; Z = OEt; R = cellobiosyl
b, Y = H; Z = OEt; R = maltosyl
c, Y = Ph; Z = SEt; R = cellobiosyl

D-glucosyl = 2,3,4,6-tetra-*O*-acetylglucopyranosyl

D-galactosyl = 2,3,4,6-tetra-*O*-acetylgalactopyranosyl

maltosyl = hepta-*O*-acetylmaltosyl

cellobiosyl = hepta-*O*-acetylcellobiosyl

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