cholecalciferol (3) (*ca.* 5 mg) was obtained. The yield of 2β-OH–D_3 (3) was calculated as 5.2 mg [λ_{max}^{Ether}: 264 nm (ε 18300 taken as standard for calculation)[37] and λ_{min}^{Ether}: 228 nm]. The NMR spectrum ($CDCl_3$) of 3 showed the characteristic resonances of the olefinic protons with vitamin D chromophore and the chemical shifts of these and C_2-protons almost identical with those observed in 2β-hydroxy-17-nor-17,17-ethylenedioxy-vitamin D[35]; τ 3.55 (1H, d, J=11 Hz) and 3.95 (1H, d, J=11 Hz) (6- and 7-H), 4.73 (1H, d, J=2 Hz) and 5.00 (1H, d, J=2 Hz) (19-H_2), 5.67 (1H, m) and 5.93 (1H, m) (2- and 3-H). The mass spectrum of 3 showed a molecular ion at *m/e* 400 and fragment ion peaks at *m/e* 382, 367, 364, 269, and 251.

37) L.F. Fieser and M. Fieser, "Steroids," Reinhold, New York, 1959, p. 148.

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Studies of Alicyclic α-Amino Acids and Their Derivatives. V.[1] Decyanization of Alicyclic α-Acetylaminonitriles with Sodium Borohydride

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Upon treatment with sodium borohydride in pyridine, 1-acetylamino-*cis*-4-*t*-butylcyclohexane-1-carbonitrile, 2-acetylaminonorbornane-*endo*-2-carbonitrile and 2-acetylaminobornane-*endo*-2-carbonitrile underwent decyanization to give a mixture of isomeric acetylamino compounds in high yields, respectively. The product distribution can be explained in terms of the preferential attack of a hydride ion on the less-hindered side of the molecules.

In a previous report from our laboratory,[1] the stereochemical courses of the Strecker and Bucherer reactions in the synthesis of alicyclic α-amino acids have been proposed, *i.e.*, the former reaction gives the α-amino acids corresponding to thermodynamically stable alicyclic α-aminonitriles, whereas the latter reaction leads to the predominant formation of the isomeric α-amino acids which are derived from alicyclic α-aminonitriles formed under the kinetic control.

Yamada, *et al.*[3] have exploited the decyanization of various α-aminonitriles possessing a hydrogen at the α-position with sodium borohydride and applied this procedure to the synthesis of some natural products.

The subject of the present investigation is to examine the stereochemistry of the decyanization on the carbon substituted by an α-aminonitrile function. For the purpose, we attempted decyanization of some alicyclic α-acetylaminonitriles, which have definite stereochemistry and are readily available *via* the Strecker reaction of the corresponding alicyclic ketones followed by acetylation.

The reduction of 1-acetylamino-*cis*-4-*t*-butylcyclohexane-1-carbonitrile[4] (I) with excess sodium borohydride in pyridine at 95° completed after 12 hr (disappearance of I was checked by thin-layer chromatography). Employment of other solvents (ethanol or diglyme) did not give satisfactory results. Careful post-treatment of the reaction mixture gave a solid

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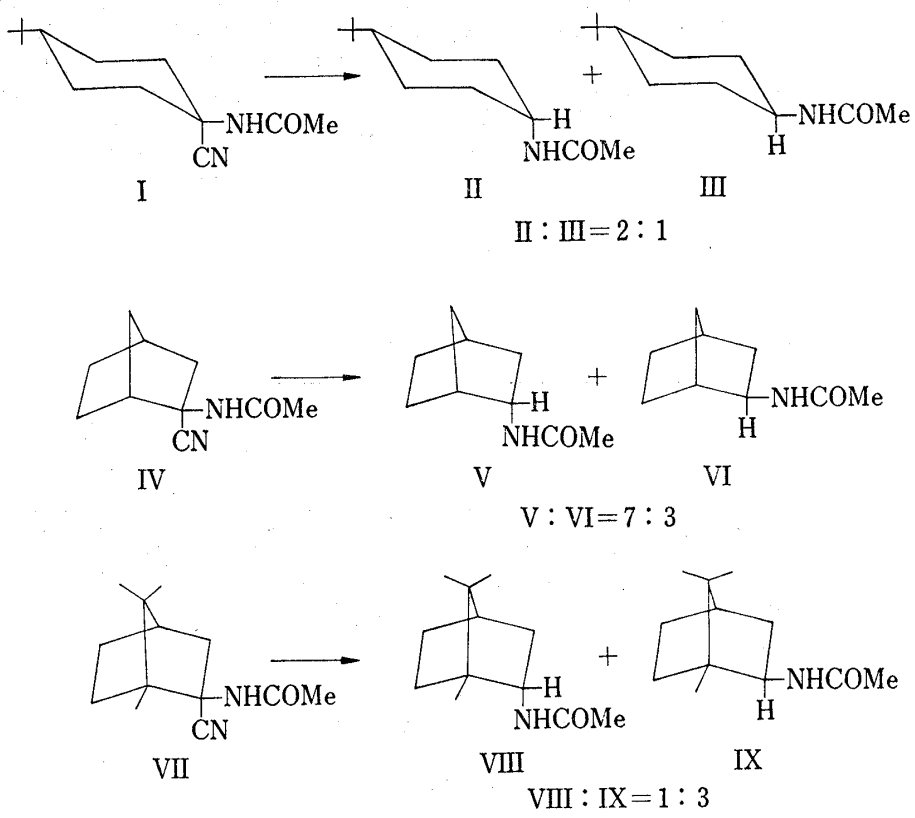
2) Location: *492–36, Mitahora, Gifu.*
3) S. Yamada and H. Akimoto, *Tetrahedron Letters*, **1969**, 3105.
4) L. Munday, *J. Chem. Soc.*, **1961**, 4372.



mixture of products in about 90% yield. The nuclear magnetic resonance (NMR) spectrum of the mixture showed the presence of two products which were identified as 1-acetylamino-*cis*-4-*t*-butylcyclohexane (II) and 1-acetylamino-*trans*-4-*t*-butylcyclohexane (III), respectively, by the NMR spectral comparison with authentic samples.[5] The ratio of isomers (II: III) in the mixture was estimated to be 2: 1 on the basis of integration of their acetyl signals in the NMR spectra and of their peaks in the gas chromatogram.

2-Acetylaminonorbornane-*endo*-2-carbonitrile (IV)[6] and 2-acetylaminobornane-*endo*-2-carbonitrile (VII)[7] were reduced under analogous conditions to give the mixture of two isomers in about 89% and 95% yields, respectively. The NMR spectra of both mixtures were analyzed by comparison with the NMR spectra of authentic samples.[8,9] Above experiments showed that the reduction of IV leads to the predominant formation of *endo*-2-acetylaminonorbornane (V), while VII gives *exo*-2-acetylaminobornane (IX) preferentially. The ratios of isomeric products in the reduction of I, IV and VII are summarized in the Chart.

The results point that the decyanization of alicyclic α-aminonitriles with sodium borohydride in pyridine are not highly stereoselective. Although the detailed mechanism on this type of reductive decyanization is not clear, the product distributions of the present experiments could show that the decyanization under the employed conditions proceeds *via* the formation of carbonium ion in a large extent and preferential attack of a hydride ion on the less hindered side of the species. A sharp contrast of product distributions between norbornanone and bornanone systems, IV and VII, which favor the *exo*-side and *endo*-side attacks of reagents, respectively, accommodates to this interpretation.

5) W. Heckel and K. Heyder, *Chem. Ber.*, **96**, 220 (1963).
6) H.S. Tagar and H.N. Christensen, *J. Am. Chem. Soc.*, **94**, 968 (1972).
7) H.L. Hoyer, *Chem. Ber.*, **83**, 491 (1950).
8) L.H. Zalkow and A.C. Oehlschlager, *J. Chem. Soc.*, **1963**, 3303.
9) M.O. Foster, *J. Chem. Soc.*, **1898**, 386.

Experimental

All melting points are uncorrected. Gas chromatographic analyses were performed on a Hitachi 023 instrument employing a 1.5 m × 3 mm stainless steel column packed with 30% SE-30. IR spectra were recorded with a Hitachi 215 spectrometer. NMR spectra were measured on a Hitachi R-20B spectrometer (60 Mc) with tetramethylsilane as an internal standard.

Materials——1-acetylamino-*cis*-4-*t*-butylcyclohexane-1-carbonitrile (I), 2-acetylaminonorbornane-*endo*-2-carbonitrile (IV) and 2-acetylaminobornane-*endo*-2-carbonitrile (VII) were prepared upon treatment of the corresponding α-aminonitriles[4,6,7] with Ac_2O–pyridine. I: mp 142.5°. *Anal.* Calcd. for $C_{13}H_{22}ON_2$: C, 70.23; H, 9.97; N, 12.60. Found: C, 70.27; H, 9.85; N, 12.72. IR cm^{-1} (KBr): 3330 (NH), 2250 (CN), 1675 (CO). NMR ($CDCl_3$) τ: 4.10 (1H, broad, NH), 7.80 (3H, singlet, $COCH_3$). IV: mp 162°. *Anal.* Calcd. for $C_{10}H_{14}ON_2$: C, 67.38; H, 7.92; N, 15.72. Found: C, 67.26; H, 7.93; N, 15.46. IR cm^{-1} (KBr): 3280 (NH), 2250 (CN), 1650 (CO). NMR ($CDCl_3$) τ: 1.64 (1H, broad, NH), 8.16 (3H, singlet, $COCH_3$). VII: mp 130.5°. *Anal.* Calcd. for $C_{13}H_{20}ON_2$: C, 70.87; H, 9.15; N, 12.72. Found: C, 70.76; H, 9.15; N, 12.73. IR cm^{-1} (KBr): 3370, 3280 (NH); 2250 (CN). 1675 (CO). NMR ($CDCl_3$) τ: 3.85 (1H, broad, NH), 7.70 (3H, singlet, ($COCH_3$).

Decyanization of 1-Acetylamino-*cis*-*t*-butylcyclohexane-1-carbonitrile (I) with Sodium Borohydride——A mixture of I (1.0 g, 0.0045 mole) and $NaBH_4$ (0.8 g, 0.02 mole) in pyridine (30 ml) was heated at 95° for 12 hr. During this period, the reaction almost completed. Disappearance of I was checked by thinlayer chromatography. After removal of pyridine from the reaction mixture under reduced pressure, the residue was extracted with $CHCl_3$ repeatedly. The combined $CHCl_3$ extract was washed with H_2O and dried over anhydrous Na_2SO_4. The residue obtained after evaporation of $CHCl_3$ (0.85 g) was proved to be a mixture of II and III by the NMR spectral and gas chromatographic comparison with authentic samples.[5] The ratio of II to I was estimated to be 2:1 on the basis of integration of their acetyl signals in the NMR spectra and of their peaks in the gas chromatogram. II was separated from the mixture by silica gel chromatography ($CHCl_3$: MeOH=20:1) and recrystallized from ether–*n*-hexane. II: mp 176°. *Anal.* Calcd. for $C_{12}H_{23}ON$: C, 73.04; H, 11.75; N, 7.10. Found: C, 72.82; H, 11.74; N, 7.10. IR cm^{-1} (KBr): 3290 (NH), 1635 (CO). NMR ($CDCl_3$) τ: 4.40 (1H, broad, NH), 5.90 (1H, broad, C_1–H), 7.92 (3H, singlet, $COCH_3$). II was identical in every respect with an authentic sample.[5]

Decyanization of 2-Acetylaminonorbornane-*endo*-2-carbonitrile (IV) with Sodium Borohydride——A mixture of IV (0.5 g, 0.0028 mole) and $NaBH_4$ (0.5 g, 0.014 mole) in pyridine (20 ml) was heated at 95° for 6 hr. After removal of pyridine under reduced pressure, the residue was extracted with $CHCl_3$ repeatedly. The $CHCl_3$ extract was washed with H_2O and dried over anhydrous Na_2SO_4. The extract was concentrated under reduced pressure to leave a solid residue (0.48 g) which is a mixture of V and VI. The ratio of V to VI was determined to be 7:3 by the NMR spectroscopy and gas chromatography. V was separated from the mixture by column chromatography using silica gel ($CHCl_3$:MeOH=20:1) and recrystallized from ether–*n*-hexane. V: mp 130°. *Anal.* Calcd. for $C_9H_{15}ON$: C, 70.55; H, 9.87; N, 9.14. Found: C, 70.55; H, 9.77; N, 8.85. IR cm^{-1} (KBr): 3310 (NH), 1640 (CO). NMR (DMSO-d_6) τ: 2.20 (1H, broad, NH), 6.10 (1H, broad, C_2–H), 8.22 (3H, singlet, $COCH_3$). V was identical in every respect with an authentic sample.[8]

Decyanization of 2-Acetylaminobornane-*endo*-2-carbonitrile (VII) with Sodium Borohydride——A mixture of VII (1.0 g, 0.0045 mole) and $NaBH_4$ (0.8 g, 0.02 mole) in pyridine (20 ml) was heated at 95° for 5 hr. The reaction mixture was concentrated under reduced pressure to remove pyridine as much as possible. The residue was extracted with $CHCl_3$ repeatedly. The $CHCl_3$ extract was washed with H_2O and dried over anhydrous Na_2SO_4. The solid residue obtained after removal of $CHCl_3$ (0.55 g) was proved to be a mixture of VIII and IX (VIII:IX=1:3) by the NMR spectroscopy and gas chromatography. Isolation of IX from the mixture was achieved by silica gel chromatography ($CHCl_3$:MeOH=20:1). IX thus obtained, mp 144°, was identical in every respect with an authentic sample.[9] *Anal.* Calcd. for $C_{12}H_{21}ON$: C, 73.79; H, 10.84; N, 7.17. Found: C, 73.99; H, 10.92; N, 6.97. IR cm^{-1} (KBr): 3325 (NH), 1640 (CO). NMR ($CDCl_3$) τ: 4.40 (1H, broad, NH), 6.0 (1H, broad, C_2–H), 8.03 (3H, singlet, $COCH_3$).