Bicyclo[3.3.1]nonanes as Synthetic Intermediates. XVI.[1,2] On the Selectivity in the Ring Enlargement of the Bicyclo[3.3.1]nonan-2-one System

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The stereochemistry in determining the migratory aptitude in the ring-expansion of bicyclo[3.3.1]nonane-2,6-dione 6-ethylene acetal (7) is discussed. The Tiffeneau–Demjanov ring-expansion of 6β-aminomethyl-6α-hydroxybicyclo[3.3.1]nonan-2-one 2-ethylene acetal (5, *endo*-alcohol) gave the homologous ketones (13 and 14) in the ratio of *ca.* 8:1, together with the *endo*-oxide (8). The reaction of the epimeric isomer, 6α-aminomethyl-6β-alcohol (6, *exo*-alcohol) gave the ketones 13 and 14 in the ratio of 2:1. The difference in the selectivity between two epimers was well interpreted in terms of least motion theory and the conformational stability of the intermediates. Hydrolysis of 13 and 14 led to two novel tricyclic systems, an isotwistane (15) and a protoadamantane (17), respectively.

Keywords bicyclo[3.3.1]nonan-2-one; Tiffeneau–Demjanov reaction; ring-expansion; migratory aptitude; bicyclo[4.3.1]-decanedione; conformational analysis; aldol cyclization; protoadamantane; isotwistane

There is continuing interest in application of the reaction of bridged ketones with diazoalkanes and of bridged β-aminohydrins with nitrous acid to the synthesis of higher homologues of the bridged systems.[3] Skeletons which have been obtained by such methods include dehydrohomoadamantane,[4a] basketane,[4b] homobrexane,[4c] triblattane,[4d] several adamantane homologues,[4e] and other cage compounds.[4f] We have developed a facile synthetic route to two novel tricyclic systems, protoadamantane (**1**) and isotwistane (**2**), *via* the ring-expansion of bicyclo[3.3.1]-nonanediones (**3**) followed by the intramolecular aldol cyclization of the ring-expanded products, bicyclo[4.3.1]-decanediones (**4**).[2,5] We also re-examined the diazomethane-triggered ring-expansion of the bicyclo[3.3.1]nonan-2-one system, revising the results reported by previous workers.[1] In this paper, we describe detailed studies on the stereochemistry in determining the migratory aptitude in the system by use of two epimeric β-aminohydrins, 6β-aminomethyl-6α-hydroxybicyclo[3.3.1]nonan-2-one 2-ethylene acetal (**5**) and its epimeric isomer (**6**).

1 2 3 4

Chart 1

Preparation of Amino-alcohols 5 and 6 The reaction of bicyolo[3.3.1]nonane-2,6-dione 6-ethylene acetal (**7**)[2,6] with trimethylsulfonium iodide[7] proceeded in a highly stereoselective manner to give mainly an *endo*-oxide (**8**) in 86% yield. The preferential attack of nucleophiles on **7** from the axial direction (*exo* or β side) is well established,[8] and the product showed high homogeneity on gas-liquid partition chromatography (GLPC) and thin layer chromatography (TLC) analysis.[9] It was treated with sodium azide in the presence of tetrabutylammonium bromide (TBAB) to give an azido-alcohol, 6β-azidomethyl-6α-hydroxybicyclo[3.3.1]nonan-2-one 2-ethylene acetal (**10**), in 92% yield. The lithium aluminum hydride (LAH) reduction of **10** gave the corresponding amino-alcohol (**5**, 90% yield), which was identical in terms of physical and spectroscopic properties with a specimen obtained *via* an alternative route.[10]

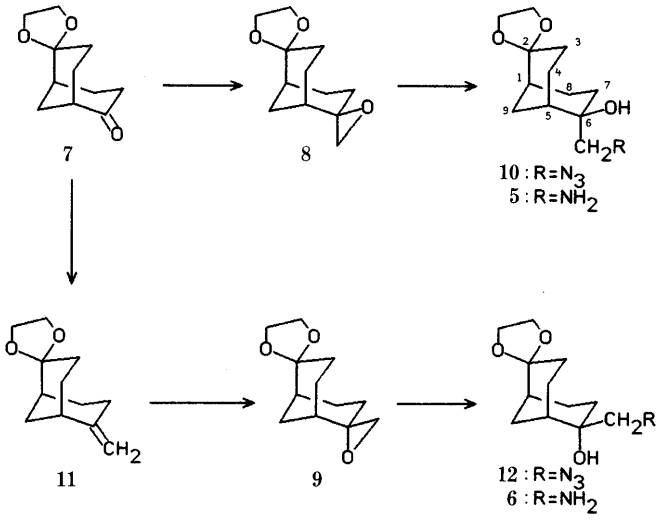

Chart 2

The epimeric amino-alcohol (**6**) was synthesized as follows. The Wittig reaction of **7** with methyltriphenylphosphonium bromide gave 6-methylenebicyclo[3.3.1]nonan-2-one 2-ethylene acetal (**11**) in 80% yield. The epoxidation of **11** with *m*-chloroperbenzoic acid gave a mixture of two epimeric oxide isomers (**8** and **9**). The product distribution of **8** and **9** was estimated to be *ca.* 1:5 on the basis of the integrated ratio of two multiplets, at δ 2.28 and 2.32, due to the C_5 methine proton in the 500 MHz proton nuclear magnetic resonance (^{1}H-NMR) spectrum. The mixture was not readily separable, and was subjected to the next reaction without further purification.

Treatment of the mixture with sodium azide in the presence of TBAB gave a mixture of the corresponding azido-alcohols **10** and **12**, and separation of each alcohol was effected by column chromatography. The physical and spectroscopic properties of the minor component (**10**) were completely in accordance with those of the specimen obtained above. The LAH reduction of the major product (**12**) gave the desired *endo*-aminomethyl-*exo*-alcohol (**6**) in 85% yield.

Diazotization of the Amino-alcohols 5 and 6 The amino-alcohols **5** and **6** were ring-expanded by the Tiffeneau–Demjanov method, and each product obtained was ana-

lyzed by GLPC. The relative product ratios obtained in each case are summarized in the reaction Chart 3. The structures of the ring-expanded ketones, 7,7-ethylenedioxybicyclo[4.3.1]decan-2-one (**13**) and -3-one (**14**), were assigned on the basis of their ^{13}C-NMR spectra, and those of the oxides **8** and **9** were established by spectral comparison with authentic specimens obtained in the pathway to the aminohydrins **5** and **6**. The ^{13}C-NMR spectrum of **14** showed a doublet due to C_1 at δ 26.2, while the signal of C_1, α to the ketone in **13**, appeared at δ 44.8, and thus **13** and **14** could be discriminated from each other.

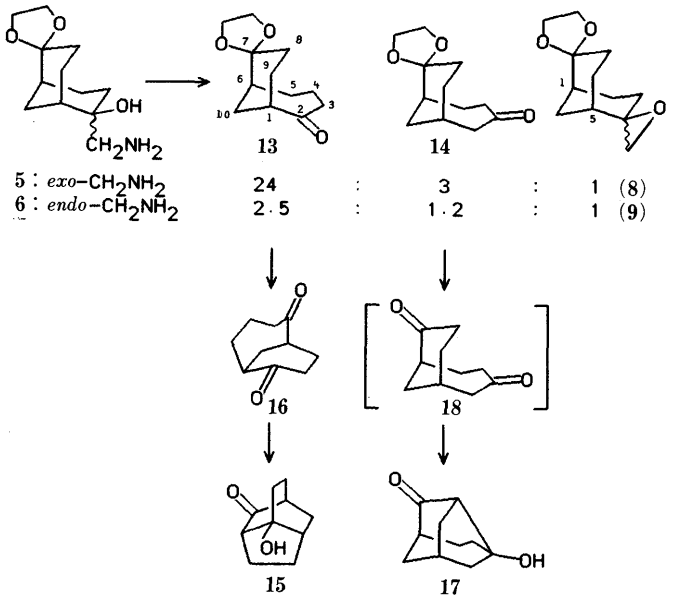

Chart 3

The results suggest that methylene migration is favored over methine migration in both the bicyclononane-6β- and -6α-carbinyl systems, and the higher selectivity was encountered with the *exo*(β)-aminomethyl system (**5**). The migratory aptitude, favoring the methylene migration to give **13**, could be interpreted in terms of a least motion argument.[11] The methylene migration can proceed by a rotation around the C_1–C_8 bond of **5A** (or around the C_5–C_6 bond of **6A**), which involves the motion of relatively few atoms in the molecule in comparison with the methine migration, which requires the motion of the bridgehead carbon and thus of most of the other atoms in the rigid bicyclic system.

The product ratio in the ring-expansion is also known to be dependent on the conformational interactions in the intermediates.[12] Maier and Schleyer[13] computed the strain energy for five possible conformations of the bicyclo[4.3.1]decane skeleton by use of the MM2 method, and found the **cb** conformation to be more stable than the **cc** conformation. With the *exo*(β)-aminomethyl system (**5**), factors favoring the methylene migration are reinforced by loss of nitrogen from **5** *via* a favorable conformation (**13cb**). In the reaction of the *endo*(α)-aminomethyl isomer (**6**), a less stable conformation (**13cc**)[13] is involved for the methylene migration; thus, the trend in selectivity is maintained but is reduced to some extent.

Conversion of 13 and 14 into Tricyclodecane Systems On treatment with 5% hydrochloric acid in dioxane, **13** gave 7-

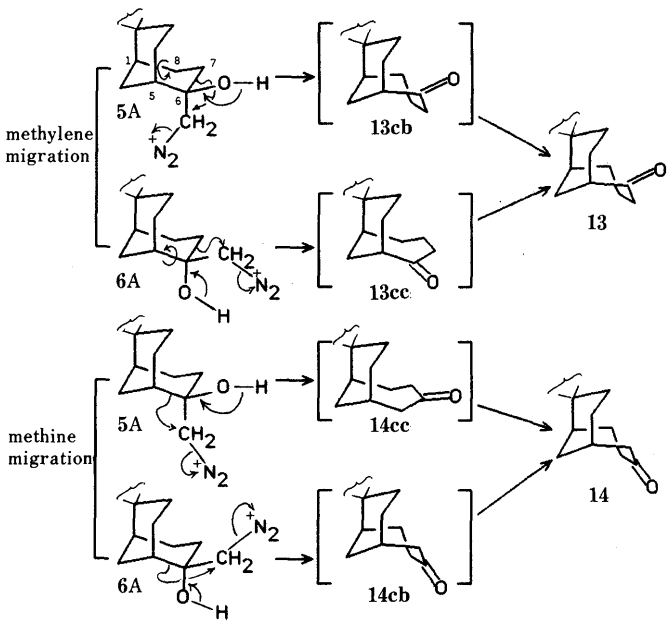

Chart 4

hydroxyisotwistan-2-one (**15**) in 92% yield while deacetalization of **13** with *p*-toluenesulfonic acid in acetone gave bicyclo[4.3.1]decane-2,7-dione (**16**) quantitatively.[2] The diketone (**16**) was relatively stable and was sublimable at 140 °C. On the other hand, acetal exchange of the isomeric ketone (**14**) with acetone at room temperature directly afforded another tricyclic hydroxy-ketone, 3-hydroxyprotoadamantan-7-one (**17**), in 90% yield. The intermediate, bicyclo[4.3.1]decane-3,7-dione (**18**), could not be detected even in a run carried out in an NMR sample tube under monitoring by ^{13}C-NMR measurements.

Intensive studies on the ring-expansion of norcamphor and dehydronorcamphor[10] have been reported; the trends in selectivity are enhanced in the 2-*endo*-norbornylcarbinyl rather than in the 2-*exo*- system. In the homologous bicyclo[3.3.1]nonane system, higher selectivity was encountered in the 2-*exo*- case. The present results elucidate the importance of the conformational stability in the transition states in determining the migratory aptitudes in the reaction, and are consistent with calculated values[13] for the conformational stability in the bicyclo[4.3.1]decane system. Conformational flexibility of the system thus enabled the intramolecular aldol cyclization to take place, and the reaction provides a general method of obtaining tricyclic skeletons from the corresponding bicycles.

Experimental

Melting points (mp) and boiling points (bp) are uncorrected. Infrared (IR) spectra were taken with a Shimadzu IR-435 grating spectrometer. ^{1}H- (200 and 500 MHz) and ^{13}C- (50 and 125 MHz) NMR spectra were recorded on a JEOL JNM-FX 200 or a JEOL JNM-GSX 500 spectrometer for $CDCl_3$ solution with tetramethylsilane as an internal standard. Coupling constants (J) are given in hertz (Hz), and the following abbreviations are used; s=singlet, d=doublet, t=triplet, q=quartet, m=multiplet, br=broad peak. All the mass spectra (MS) and high-resolution mass spectra (HRMS) were taken on a JEOL JMS-HX 100 mass spectrometer. GLPC was carried out on a Shimadzu GC-9A gas chromatograph, equipped with a glass column (2 mm × 2 m) packed with 10% polyethylene glycol on Chromosorb W (60—80 mesh) with N_2 carrier gas at a flow rate of 40 ml/min. All the column chromatographies were performed using LiChroprep Si 60 (Merck Art. 9319) with a pump (FMI

Model RP-SY). All the organic extracts were dried over anhydrous magnesium sulfate prior to evaporation.

Bicyclo[3.3.1]nonane-2,6-dione 6-Ethylene Acetal (7) Following the published method,[2] **7** was prepared from bicyclo[3.3.1]nonane-2,6-dione in 92% yield, bp 147—150 °C (2 mmHg), lit.,[6] bp 120—123 °C (1 mmHg).

Reaction of Dimethylsulfonium Methylide with 7 to Give the Oxide (8) A suspension consisting of sodium hydride [60% dispersion in liquid paraffin, 1.5 g, 38 mmol, washed three times with dry tetrahydrofuran (THF)], dry dimethylsulfoxide (DMSO, 30 ml), and dry THF (60 ml) was stirred at 0 °C for 0.5 h under an argon atmosphere. To this were added dropwise a solution of trimethylsulfonium iodide (8.0 g, 39 mmol) in dry DMSO (50 ml) and a solution of **7** (6.5 g, 33 mmol) in dry THF (50 ml) successively. The resulting mixture was stirred at 0 °C for 1 h, and then at room temperature for 3 h. The mixture was poured into ice-water and extracted with ether. The extract was washed with brine and evaporated to give 6.8 g of a pale yellow oil, which on distillation under reduced pressure gave 6.0 g (86%) of a colorless oil, bp 118—120 °C (3 mmHg). IR (film); 2900, 1478, 1453, 1378, 1328, 1256, 1235, 1200, 1138, 1110, 1043, 1028, 985, 968, 946, 930, 915, 897, 843, 808 cm^{-1}. ^{1}H-NMR (500 MHz) δ: 1.25—1.34 (2H, m), 1.62—2.14 (9H, m), 2.28 (1H, dt, J=14.0, 7.0), 2.57 (1H, dd, J=5.0, 1.5), 2.60 (1H, d, J=5.0), 3.83—4.02 (4H, m). ^{13}C-NMR (50 MHz) δ: 24.9 (t), 25.1 (t), 29.0 (t), 31.5 (t), 31.9 (t), 35.3 (d), 36.0 (d), 57.6 (t), 61.1 (s), 64.2 (t) 64.4 (t), 110.7 (s). MS m/z (%): 210 (M^+, 4), 208 (4), 192 (11), 181 (39), 179 (30), 164 (13), 154 (23), 153 (100), 90 (52), 79 (59). HRMS m/z: 210.1256 ($C_{12}H_{18}O_3$ requires 210.1256).

6β-Azidomethyl-6α-hydroxybicyclo[3.3.1]nonan-2-one 2-Ethylene Acetal (10) A mixture of sodium azide (5.5 g, 85 mmol), the oxide (**8**, 5.10 g, 24 mmol), TBAB (200 mg), dimethoxyethane (DME, 70 ml), and water (20 ml) was heated under reflux with vigorous stirring for 30 h. Brine (80 ml) was added, and the resulting mixture was extracted with ether. The extract was washed with brine and evaporated to give 5.65 g (92%) of **10** as a pale yellow oil, which solidified on standing. mp 47—49 °C. IR (film); 3420, 2900, 2050, 1470, 1452, 1375, 1317, 1280, 1240, 1140, 1107, 1085, 1026, 915, 850 cm^{-1}. ^{1}H-NMR (200 MHz) δ: 1.36—2.24 (13H, m), 3.43 (1H, *A* part of CH_2N_3, J=13.0), 3.53 (1H, *B* part of CH_2N_3, J=13.0), 3.84—4.04 (4H, m). ^{13}C-NMR (50 MHz) δ; 23.4 (t), 23.7 (t), 29.3 (t), 31.4 (t), 32.2 (t), 34.3 (d), 36.0 (d), 59.2 (t), 64.1 (t), 64.3 (t), 74.0 (s), 110.3 (s). MS m/z (%): 253 (M^+, 0.3), 225 (7), 197 (22), 196 (38), 153 (19), 127 (31), 113 (41), 112 (41), 98 (100), 85 (54), 54 (87). HRMS m/z: 225.1360 ($C_{12}H_{19}N_3O_3-N_2$ requires 225.1365). MS (FAB) m/z: 254 [$(M+1)^+$].

6β-Aminomethyl-6α-hydroxybicyclo[3.3.1]nonan-2-one 2-Ethylene Acetal (5) A suspension consisting of LAH (100 mg), **10** (309 mg), and dry THF (20 ml) was heated under reflux for 8 h with vigorous stirring. Excess hydride was decomposed with ethyl acetate. To this mixture, 10% aqueous sodium hydroxide solution was added, and the resulting gel was washed with THF several times. The washings were combined and evaporated to give 250 mg (90%) of **5** as a pale yellow solid (needles from benzene), mp 128—129 °C.

6-Methylenebicyclo[3.3.1]nonan-2-one 2-Ethylene Acetal (11) Dry DMSO (10 ml) was added to sodium hydride (60% dispersion in liquid paraffin, 650 mg, 16 mmol, washed with petroleum ether) under an argon atmosphere, and the mixture was stirred at 80 °C for 1 h and cooled. After addition of a solution of methyltriphenylphosphonium bromide (5.8 g, 16 mmol) in dry DMSO (20 ml) to the mixture followed by stirring at 0 °C for 0.5 h and subsequently by addition of a solution of **7** (2.1 g, 11 mmol) in dry DMSO (2 ml), the resulting mixture was stirred at room temperature for 1 h, then poured into ice-water (50 ml), and extracted with pentane. The extract was washed with water and evaporated to give 1.80 g of a pale yellow oil, which on distillation under reduced pressure gave 1.66 g (80%) of **11** as a colorless oil, bp 92—94 °C (2 mmHg). IR ($CHCl_3$): 2930, 1638, 1449, 1379, 1110, 1085, 1037, 1030, 977, 947, 914, 890 cm^{-1}. ^{1}H-NMR (500 MHz) δ: 1.55—2.02 (9H, m), 2.31 (1H, ddd, J=16.0, 7.5, 2.5), 2.42—2.59 (2H, m), 3.85—4.03 (4H, m), 4.64 (2H, m). ^{13}C-NMR (50 MHz) δ: 25.9 (t), 30.1 (t), 30.4 (t), 31.9 (t), 32.5 (t), 36.4 (d), 37.0 (d), 64.2 (t), 64.4 (t), 107.7 (t), 110.0 (s), 152.3 (s). MS m/z (%): 194 (M^+, 7), 100 (7), 99 (100), 86 (13), 79 (3), 77 (3), 55 (7). HRMS m/z: 194.1300 ($C_{12}H_{18}O_2$ requires 194.1307).

Reaction of 11 with *m*-Chloroperbenzoic Acid: the Oxide (8 and 9) A solution of **11** (1.07 g, 5.5 mmol) and 80% *m*-chloroperbenzoic acid (1.31 g, 6.1 mmol) in dichloromethane (20 ml) was stored in a dark place for 2.5 h, and then washed with an aqueous solution of sodium thiosulfate–sodium bicarbonate. The washing was extracted with dichloromethane, and the combined organic phase was washed with brine and evaporated to give 1.12 g of a colorless oil, which on distillation under reduced pressure gave 1.0 g (86%) of a colorless oil, bp 120—124 °C (3 mmHg). The ^{13}C-NMR quantitative analysis of the oil showed the product to be a *ca.* 1 : 5 mixture of the corresponding oxides **8** and **9**, which were not readily separable on column chromatography, so the mixture was used for the next reaction without further purification. ^{1}H-NMR (500 MHz) δ: 1.20—1.34 (2H, m), 1.62—2.14 (9H, m), 2.28 (0.16H, m), 2.32 (0.84H, ddd, J=15.5, 13.0, 7.0), 2.56—2.62 (0.32H, m), 2.58 (1.68H, s), 3.83—4.02 (4H, m). ^{13}C-NMR (125 MHz) δ: 23.4 (t, A), 24.8 (t, B), 25.0 (t, B), 25.8 (t, A), 28.9 (t, B), 29.2 (t, A), 29.6 (t, A), 31.5 (t, B), 31.6 (t, A), 31.9 (t, B), 35.3 (d, B), 35.8 (d, A), 35.9 (d, A), 36.0 (d, B), 53.0 (t, A), 57.7 (t, B), 60.3 (s, A), 61.1 (s, B), 64.1 (t, B), 64.2 (t, A), 64.3 (t, A, B), 110.6 (s, A, B); A = signals for **9**, B = signals for **8**.

6α-Azidomethyl-6β-hydroxybicyclo[3.3.1]nonan-2-one 2-Ethylene Acetal (12) and Its Epimer (10) A mixture of the oxides (**8** and **9**, 733 mg, 3.5 mmol), sodium azide (1.04 g, 16 mmol), TBAB (322 mg), DME (10 ml), and water (3 ml) was heated under reflux for 24 h with vigorous stirring. Work-up in a manner similar to that described for the preparation of **10** gave 805 mg (91%) of a pale yellow solid, 630 mg of which was subjected to column chromatography [eluent; benzene–acetone (30 : 1, v/v)] to give 354 mg of **12** and 65 mg of **10**. The physical and spectroscopic properties of the minor component (**10**) were completely in accordance with those of the specimen obtained above.

endo-Azidomethyl-*exo*-alcohol (**12**): Needles (from cyclohexane), mp 91—92.5 °C. IR (KBr): 3347, 2941, 2900, 2870, 2099, 1371, 1311, 1293, 1140, 1116, 1106, 1093, 1063, 1040, 1029, 948, 915 cm^{-1}. ^{1}H-NMR (200 MHz) δ: 1.52—2.18 (13H, m), 3.30 (1H, *A* part of CH_2N_3, J=13.0), 3.34 (1H, *B* part of CH_2N_3, J=13.0), 3.80—4.00 (4H, m). ^{13}C-NMR (50 MHz) δ: 21.8 (t), 24.9 (t), 27.2 (t), 31.0 (t), 31.6 (t), 35.2 (d), 36.6 (d), 60.6 (t), 64.2 (t), 64.4 (t), 73.6 (s), 110.4 (s). MS m/z (%): 225 (M^+-N_2, 0.5), 198 (13), 197 (57), 153 (29), 136 (13), 100 (13), 99 (100), 86 (16), 83 (14), 56 (7), 55 (6). HRMS m/z: 225.1367 ($C_{12}H_{19}O_3N_3-N_2$ requires 225.1365). MS (FAB) m/z: 254 [$(M+1)^+$].

6α-Aminomethyl-6β-hydroxybicyclo[3.3.1]nonan-2-one 2-Ethylene Acetal (6) A suspension consisting of LAH (150 mg), **12** (79 mg, 0.31 mmol) and dry ether (15 ml) was sonicated for 3 h. Work-up in a manner similar to that used for the preparation of **5** gave 75 mg of a pale yellow oil, which on trituration with hexane gave 60 mg (85%) of **6** as a colorless solid, mp 84—86 °C (amorphous solid). IR (KBr): 3372, 2935, 1559, 1545, 1470, 1448, 1304, 1223, 1139, 1110, 1090, 1063, 1024, 1005, 957, 940, 912 cm^{-1}. ^{1}H-NMR (200 MHz) δ: 1.46—1.92 (11H, m), 2.14 (1H, m), 2.59 (1H, *A* part of CH_2NH_2, J=13.0), 2.69 (1H, *B* part of CH_2NH_2, J=13.0), 2.76 (3H, brs, NH_2 and OH), 3.80—4.02 (4H, m). ^{13}C-NMR (50 MHz) δ: 22.1 (t), 24.6 (t), 27.5 (t), 31.5 (t), 31.8 (t), 35.0 (d), 36.7 (d), 50.0 (t), 64.1 (t), 64.3 (t), 72.2 (s), 110.7 (s). MS m/z (%): 227 (M^+, 25), 197 (100), 196 (23), 153 (52), 135 (12), 110 (43), 107 (12), 100 (10), 99 (95), 86 (26), 83 (35), 55 (20). HRMS m/z: 227.1539 ($C_{12}H_{21}O_3N$ requires 227.1522).

Treatment of 5 with Nitrous Acid Sodium nitrite (290 mg, 4.2 mmol) was added to a solution of **5** (240 mg, 1.1 mmol) and acetic acid (0.8 ml) in water (10 ml) under ice-cooling, and the mixture was stirred for 3 h, neutralized with a saturated sodium bicarbonate solution, and extracted with ether. The extract was washed with brine and evaporated to give 190 mg of a colorless oil, the GLPC analysis of which showed three main peaks due to 7-ethylenedioxybicyclo[4.3.1]decan-2-one (**13**), -3-one (**14**), and the 2-*endo*-oxide (**8**) in the ratio of 24 : 3 : 1. One hundred and sixty milligrams of the oil was subjected to column chromatography [eluent; hexane–acetone (5 : 1, v/v)] to give 110 mg of **13**, 15 mg of **14**, and 6 mg of **8**. The spectroscopic properties of both **13** and **8** were completely in accordance with those of authentic specimens.

13: bp 156—158 °C (5 mmHg).

14: bp 155—160 °C (5 mmHg). IR ($CHCl_3$): 2929, 1690, 1466, 1444, 1375, 1299, 1263, 1234, 1207, 1110, 1094, 1024, 968, 944, 910 cm^{-1}. ^{1}H-NMR (500 MHz) δ: 1.52—2.06 (8H, m), 2.06—2.16 (2H, m), 2.37—2.52 (3H, m), 2.66 (1H, dd, J=12.5, 6.5), 3.88—4.03 (4H). ^{13}C-NMR (125 MHz) δ: 23.7 (t), 26.2 (d), 26.8 (t), 28.6 (t), 30.0 (t), 38.5 (d), 40.1 (t), 45.7 (t), 64.2 (t), 64.3 (t), 110.6 (s), 213.9 (s). MS m/z (%): 210 (M^+, 18), 153 (3), 127 (4), 125 (5), 112 (3), 100 (9), 99 (100), 87 (3), 86 (26), 67 (2), 55 (5). HRMS m/z: 210.1241 ($C_{12}H_{18}O_3$ requires 210.1256).

Treatment of 6 with Nitrous Acid One hundred and ninety milligrams (0.84 mmol) of **6** was treated with sodium nitrite (230 mg, 3.3 mmol) and worked up in a manner similar to that described for the reaction of **5** to give 145 mg of a colorless oil. The GLPC analysis of the crude product showed three peaks due to **13**, **14**, and **9** in the ratio of 2.5 : 1.2 : 1. One hundred and thirty milligrams of the oil was subjected to column chromatography [eluent; hexane–acetone (5 : 1, v/v)] to give 58 mg of **13**, 24 mg of **14**, and 18 mg of **9**. The physical and spectroscopic properties of

13 and **14** were completely in accordance with those of authentic specimens.

Deacetalization of 13 to Give Bicyclo[4.3.1]decane-2,7-dione (16) Following the published method,[2] conversion of **13** to **16** was carried out to give **16** in 97% yield, mp 118—119 °C, lit.,[14] mp 117.3—118.6 °C.

Deacetalization of 13 to Give 7-Hydroxyisotwistan-2-one (15) Following the published method,[2] conversion of **13** to **15** was carried out to give **15** in 92% yield, mp 213—216 °C,[15] lit., mp 121—123 °C,[16a] mp 104—108 °C.[16b]

Deacetalization of 14 to Give 3-Hydroxyprotoadamantan-7-one (17) A solution of **14** (105 mg, 0.50 mmol) and a catalytic amount of *p*-toluenesulfonic acid (TsOH) in acetone was stirred at room temperature for 1 h, then neutralized with a saturated sodium bicarbonate solution, and concentrated under reduced pressure. The residue was extracted with ether. The extract was washed with brine and evaporated to give 80 mg of a colorless solid, which on sublimation at 150 °C (15 mmHg) gave 75 mg (90%) of **17** as a colorless solid, the physical and spectroscopic properties of which were completely in accordance with those of an authentic specimen,[1] mp 258—260 °C (in a sealed tube).

Deacetalization of 14 under Monitoring by ^{13}C-NMR Measurements An acetone-d_6 (0.5 ml) solution of **14** (30 mg) in an NMR sample tube was treated with TsOH (2 mg), and the mixture was spun for 3 h, during which period 12 spectra were collected with a JEOL JNM-FX 200 spectrometer. No signals other than those for **14** and/or **17** were detected in any spectrum.

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References and Notes

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10) In the previous communication, we reported a one-pot synthesis of **5** involving trimethylsilylcyanation of bicyclo[3.3.1]nonane-2,6-dione 6-ethylene acetal (**7**) and subsequent lithium aluminum hydride reduction (see ref. 2). In the present study, an *endo*-oxide (**8**) was needed for the identification of the minor product in both the rearrangement of **5** and the epoxidation of **11**. In addition, it was found easy to fractionate the epimers by column chromatography at the stage of the azido-alcohols **10** and **12**, and thus a conventional route was preferred.
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