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AN UNUSUAL REARRANGEMENT OF THE TETRACYCLO[10.2.1.$0^{2,11}$.$0^{4,9}$]PENTADECANE SKELETON

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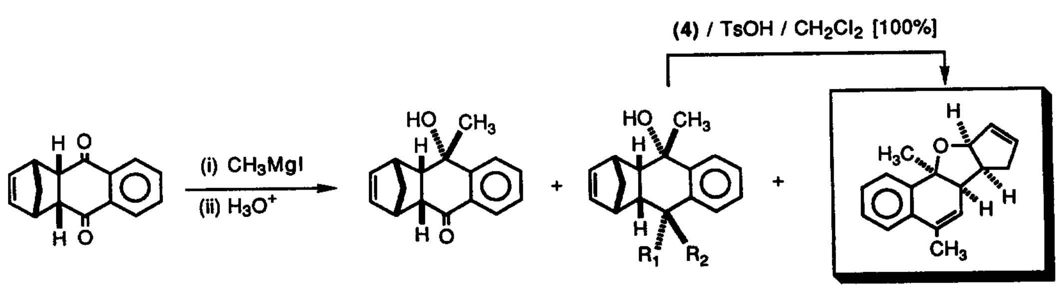
Summary: The diol **4** undergoes acid catalysed rearrangement to the cyclic ether **5** in a process involving C1-C2 cleavage of a norbornyl unit.

In the course of a study[1] aimed at the synthesis of variously substituted naphthonorbornadienes we had occasion to investigate reaction of the naphthoquinone-cyclopentadiene Diels-Alder adduct **1** with excess methyl magnesium iodide. In addition to small amounts of the mono-addition product **2**[2] and the symmetrical diol **3**[3] the major product was the unsymmetrical diol **4**[4], which results from a chelation controlled addition of the second Grignard equivalent to the opposite (endo-) face of the second carbonyl group of **2**. Also obtained were variable amounts (5-25%) of a further product which was subsequently shown to result from rearrangement of **4**. Indeed reaction of **4** with p-toluenesulphonic acid in dichloromethane solution afforded **5** in quantitative yield.



(1)

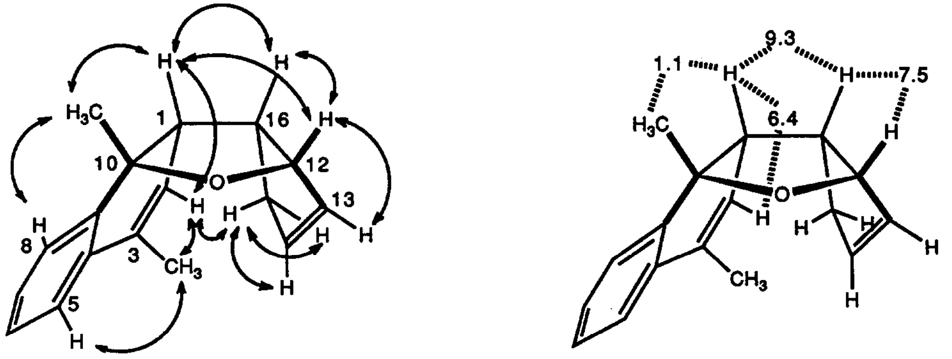
(2) [5%]

(3) R_1 = OH, R_2 = CH_3 [10%]
(4) R_1 - CH_3, R_2 = OH [55-80%]

(5) [5-25%]

The structure of this product was deduced to be the cyclic ether **5** from spectroscopic data[5] as follows. High resolution mass spectrometry indicated the molecular formula $C_{17}H_{18}O$. The absence of hydroxyl or carbonyl stretches in the infrared spectrum indicated an ether oxygen which was shown by NMR to be attached to a quaternary and a mono-protonated carbon. The presence of an ortho-disubstituted benzene ring was indicated by the infrared and NMR spectra, the latter also showing the presence of three olefinic protons and two methyl groups, one of which was attached to a double bond. These features require a tetracyclic ether structure, the basic skeleton of which was deduced from a series of one and two dimensional NMR experiments. Particularly informative were the observed NOE enhancements and spin-spin coupling constants shown in Figure 1, which also revealed the two cis ring fusions[6].

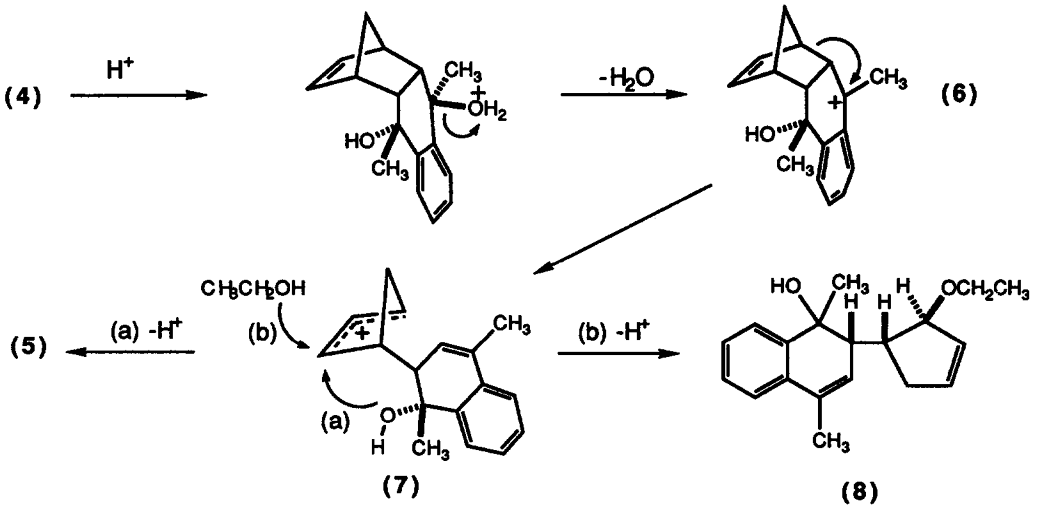
Figure 1.



(a) Observed NOE enhancements

(b) Selected ^1H-^1H coupling constants

A mechanism for the formation of **5** is shown opposite and involves initial ionisation of the (more accessible) exo hydroxyl group to give a tertiary benzylic carbocation **6**, which undergoes an unusual cleavage of the adjacent norbornyl group to give the allylic cation **7**, which in turn undergoes intramolecular nucleophilic capture by the hydroxyl group[7]. Further evidence for the intermediacy of **7** comes from the observation that an attempted recrystallisation of **4** from ethanol gave a mixture of two diastereomeric hydroxy-ethers which were assigned structures **8**, and which result from competitive intermolecular capture of **7** by ethanol[8]. A number of multistep syntheses of the oxa-C-nor-steroid ring skeleton of **5** have been previously described[9-11]; the present three step route is both high yielding and from readily available starting materials.



References and Notes

(1) O'Connell, M.J.; Ph.D. Thesis, University of Canterbury, 1987.

(2) Selected data for **2**: ν_{max} 3450, 3000, 1670 cm^{-1}. ^{1}H NMR δ 1.43, s, Me; 1.45, m, 2H; 1.88, OH; 2.93, dd, 2H; 3.22, br s, 1H; 3.32, br s, 1H; 3.34, dd, 1H; 5.43, dd, 1H; 5.58, dd, 1H; 7.27, m, 1H; 7.57, m, 3H. ^{13}C NMR δ 37.8, 46.1, 49.9, 50.0, 50.1, 51.3, 71.6, 123.4, 125.7, 126.9, 133.7, 133.9, 134.4, 133.6, 148.2, 200.8. (Found: $M^{+\cdot}$, 240.1155. $C_{16}H_{16}O_2$ requires: $M^{+\cdot}$, 240.1150).

(3) Selected data for **3**: m.p. 224°. ν_{max} 3450, 3200 cm^{-1}. ^{1}H NMR δ 1.42, dt, 1H; 1.56, d, 1H; 1.76, s, Me$_2$; 2.44, t, 2H; 3.11, m, 2H; 6.27, t, 2H; 7.31, dd, 2H; 7.55, dd, 2H. ^{13}C NMR δ 27.0, 44.8, 51.3, 52.4, 71.1, 124.2, 127.6, 133.7, 143.7. (Found: $M^{+\cdot}$, 256.1444. $C_{17}H_{20}O_2$ requires: $M^{+\cdot}$, 256.1463).

(4) Selected data for **4**: ν_{max} 3450, 3000 cm^{-1}. ^{1}H NMR δ 1.27, dt, 1H; 1.37, d, 1H; 1.72, s, Me; 1.76, s, Me; 2.82, dd, 1H; 2.93, dd, 1H; 2.94, br s, 1H; 3.08, br s, 1H; 5.22, dd, 1H; 5.40, dd, 1H; 7.24, m, 3H, 7.59, dd, 1H. ^{13}C NMR δ 28.2, 36.0, 46.6, 46.9, 48.7, 50.1, 50.3, 71.0, 72.6, 122.8, 123.9, 126.4, 128.1, 132.9, 133.8, 139.2, 144.9. (Found: $M^{+\cdot}$, 256.1477. $C_{17}H_{20}O_2$ requires: $M^{+\cdot}$, 256.1463).

(5) Selected data for **5**: ν_{max} 2950, 1090, 1020, 765 cm^{-1}. ^{1}H NMR δ 1.37, br s, 10-Me; 1.90, dddd, $J_{15b,14}$ 2.2Hz, $J_{15b,13}$ 2.3Hz, $J_{15b,16}$ 4.2Hz, $J_{15b,15a}$ 17.8Hz, H15b; 2.02, dddd, $J_{15a,14}$ 2.2Hz, $J_{15a,13}$ 2.2Hz, $J_{15a,16}$ 9.3Hz, $J_{15a,15b}$ 17.8Hz, H15a; 2.12, d, $J_{3\text{-}Me,2}$ 1.5Hz, 3-Me; 2.77, ddd, $J_{1,10\text{-}Me}$ 1.1Hz, $J_{1,2}$ 6.4Hz, $J_{1,16}$ 9.3Hz, H1; 3.07, dddd, $J_{16,15b}$ 4.2Hz, $J_{16,12}$ 7.5Hz, $J_{16,15a}$ 9.3Hz, $J_{16,1}$ 9.3Hz, H16; 5.23, ddd, $J_{12,13}$ 2.2Hz, $J_{12,14}$ 2.2Hz, $J_{12,16}$ 7.5Hz, H12; 5.31, dddd, $J_{14,12}$ 2.2Hz, $J_{14,15a}$ 2.2Hz, $J_{14,15b}$ 2.2Hz, $J_{14,13}$ 5.7Hz, H14; 5.44, dddd, $J_{13,15a}$ 2.2Hz, $J_{13,15b}$ 2.3Hz, $J_{13,12}$ 2.2Hz, $J_{13,14}$ 5.7Hz, H13; 5.80, dq, $J_{2,3\text{-}Me}$ 1.5Hz, $J_{2,1}$ 6.4Hz, H2; 7.15, m, H5,H6,H7; 7.42, m, H8. ^{13}C NMR δ 19.5, 3-Me; 30.4, 10-Me; 34.1, C15; 44.9, C16; 48.6, C1; 82.1, C10; 88.0, C12; 122.2, 126.4, 127.1, (C5,C6,C7); 123.9, C2; 125.7, C8; 129.8, C13; 132.9, 133.0, (C3,C4); 134.4, C14; 141.7, C9. (Found: M$^{+\cdot}$, 238.1366. $C_{17}H_{18}O$ requires: M$^{+\cdot}$, 238.1358).

(6) An MM2 minimisation was performed on **5** using BAKMDL 2.95 (1990) which revealed three low energy conformations in the Boltzmann ratio 70:27:3. Coupling constants weighted for this ratio were determined using the Karplus procedure as implimented in MODEL 2.95 (1990) and were in good agreement with the observed values. We thank Prof. Kosta Steliou for this software and for helpful discussions.

(7) The proposed norbornyl ring cleavage and intramolecular capture has a close analogy in the recently reported conversion of tricyclo[5.2.1.0^{2,6}]deca-3,8-dienes to 2-oxatricyclo[6.3.0.0^{3,7}]-undeca-4,10-dienes on treatment with periodic acid. See: Ohta, H.; Motoyama, T.; Ura, T.; Ishii, Y.; Ogawa, M.; *J. Org. Chem.* **1989**, *54*, 1668.

(8) A tricyclo[5.2.1.0^{2,6}]decenone has recently been reported to undergo fragmentation and intermolecular reaction with ethanedithiol. See: Marchand, A.P.; Vidyasagar, V.; Suri, S.C.; Thomas, R.D.; Ellington, D.H.; *J. Org. Chem.* **1989**, *54*, 3751.

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