

SHORT COMMUNICATION

1,3-ELIMINATION IN 2-(*tert*-ALKYL)ADAMANTAN-2-OLS: AN EASY SYNTHESIS OF BRIDGEHEAD-SUBSTITUTED 2,4-DEHYDROADAMANTANES

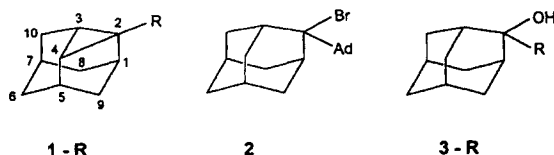
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When 2-(*tert*-alkyl)adamantan-2-ols (where the substituent is bi- or tricyclic) are thermolysed or the corresponding bromide is refluxed in pyridine, an unusual 1,3-elimination occurs, leading to 2,4-dehydroadamantanes bearing the *tert*-alkyl substituent on the cyclopropane system.

1. INTRODUCTION

2,4-Dehydroadamantane (**1-H**)¹ and related compounds² with strained cyclopropane rings have generally been prepared by the pyrolysis of the lithium or sodium salt of the appropriate *p*-tosylhydrazone. 2,4-Dehydroadamantane has, however, also been prepared by pyrolysis of the 2-adamantyl tosylate or mesylate³ and by Huang–Minlon reduction of 8,9-dehydroadamantan-2-one.⁴ It can also be prepared from this ketone via the alcohol and the chloride.⁵ It is reported to be formed (8%) in the deamination of 2-adamantylamine by the aryltriazene procedure⁶ and in the catalytic hydrogenation of 2,4,6,9-tetrahydroadamantane (10%),^{2a} and is one of the primary photoproducts from the irradiation of 2-adamantyl bromide or iodide in diethyl ether or methanol containing triethylamine.⁷ It is a minor product (2%) in the solvolysis of a 4-substituted 2-adamantyl *p*-nitrobenzenesulphonate.⁸



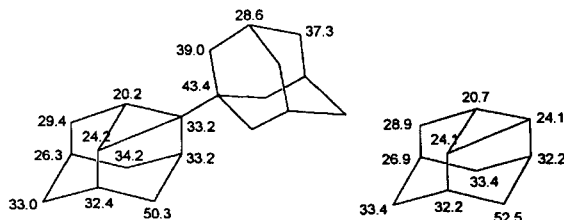
Despite all this work on the parent compound, to date only one bridgehead-substituted 2,4-dehydroadamantane has been described, the 2-methyl derivative, **1-Me**, obtained in five steps from 8,9-dehydroadamantan-2-one.⁹ We now report that a very unusual 1,3-elimination

leads to a remarkably simple synthesis of 2-(1-adamantyl)-2,4-dehydroadamantane (**1-Ad**), which can be extended to other bicyclic or tricyclic *tert*-alkyl substituents, such as 1-bicyclo[2.2.2]octyl or 1-norbornyl.

RESULTS AND DISCUSSION

When 1,2'-biadamantyl was synthesized by reduction of 2-(1-adamantyl)-2-bromoadamantane (**2**), the product was contaminated with a hydrocarbon of slightly shorter retention time. However, when the mixture was treated with bromine in carbon tetrachloride and the product was chromatographed on alumina in pentane, 1,2'-biadamantyl was obtained pure.¹⁰ ¹³C NMR on the crude material indicated that the impurity was neither of the adamantene dimers isolated by Lenoir and Firl¹¹ and McKervey and co-workers.¹² Refluxing the bromide in pyridine gives only the 'impurity' hydrocarbon, in 91% yield. Thermal dehydration of 2-(1-adamantyl)adamantan-2-ol (**3-Ad**) at 280 °C gives the same material, again in high yield. The ¹³C NMR spectrum indicates two quaternary, six tertiary (relative intensities 1, 1, 1, 3, 1, 1) and six secondary carbons (relative intensities 1, 1, 1, 3, 3, 1), corresponding to C₂₀H₂₈, the mass of 268 Da being confirmed by mass spectrometry. Coupling constants for the two upfield CH groups are high, 164 and 154 Hz, consistent with their being part of a cyclopropane system. Signals due to the 1-adamantyl substituent are easily identified by their shifts and intensities (28.6, 3 CH; 37.3, 3 CH₂; 39.0, 3 CH₂; 43.4, 1 C_q), leaving five CH, four CH₂ and one C_q,

indicating that the compound is a bridgehead-substituted 2,4-dehydroadamantane. The ^1H NMR spectrum shows a massif stretching from 1.25 to 2.0 ppm and two broad ^1H multiplets at 2.20 and 2.32 ppm. A heteronuclear correlation experiment identifies these as corresponding to CH signals at 32.4 and 33.2 ppm, respectively, of the dehydroadamantane skeleton, shown as C-1 and C-5 (not necessarily in this order) in the structure. The ^{13}C NMR spectrum closely resembles that of the parent 2,4-dehydroadamantane (**1-H**)¹³ with the characteristic downfield CH_2 signal associated with the bicyclo[3.1.0]hexyl unit^{13,14} (C-9) at 50.3 ppm (52.5 ppm in the parent). (Dehydroadamantanes and related compounds are frequently named and numbered with reference to the assumed parent compound. Strictly, 2,4-dehydroadamantane is tetracyclo[4.3.1.0^{2,4}.0^{3,8}]decane. Fortuitously, the downfield methylene carbon is C-9 in both numbering systems, but C-1 and C-5 will be C-1 and C-8, respectively, according to the correct notation.) The ^{13}C NMR assignments of the new derivative and of the parent compound are given for comparison.



Normally, there are two ways by which a carbocation gives molecular products, either by reaction with a nucleophile or by loss of a proton, although proton loss may be replaced by fragmentation leading to an alkene and a new, smaller carbocation. The proton or fragment to be eliminated should be on a carbon adjacent to the cationic centre and preferably in a position orthogonal to the plane of the carbocation. If the first condition is not initially satisfied, then a 1,2-sigmatropic (Wagner–Meerwein) rearrangement may displace the cationic centre so that it is. This is the situation for a *tert*-butyl attached to a charged carbon: there is initially no α -hydrogen but migration of one methyl group leaves the other two on the electron-deficient centre, which now has six α hydrogens. For this reason, *tert*-butyl groups often do not survive carbonium ion reactions.^{15,16} Replacing a *tert*-butyl group by a 1-adamantyl, however, greatly reduces the rate of the corresponding rearrangement so that only under forcing conditions, such as those of the Koch reaction,¹⁷ will the adamantyl system undergo ring expansion. There may therefore arise situations where it is kinetically and/or thermodynamically preferable to seek a proton elsewhere and for 1,3-elimination, rather than simple 1,2-elimination, to occur. This is clearly the case of the 2-

(1-adamantyl)adamant-2-yl cation, for which 1,3-elimination is manifestly easier than the formation of a substituted adamantene, the anti-Bredt alkene.^{11,12}

There are ample precedents for this reaction in physical chemistry. Water is eliminated from 2-adamantanol in mass spectrometry predominantly by a stereospecific 1,3-elimination from the intact skeleton (*i.e.* before α -cleavage) to give a radical cation $[\text{C}_{10}\text{H}_{14}]^{+\cdot}$ with the 2,4-dehydroadamantane structure.¹⁸ Other 2-substituted adamantanes also undergo 1,3-elimination in mass spectrometry.¹⁹ According to another report, possible isomeric structures of $[\text{C}_{10}\text{H}_{14}]^{+\cdot}$ from different precursors interconvert to a mixture of common ions.²⁰ The anodic oxidation of 2-adamantyl fluoride, but not other halides, in acetonitrile also proceeds via the 2,4-dehydroadamantyl radical cation.²¹

Analogous experiments on other 2-(*tert*-alkyl)adamantan-2-ols, where the tertiary alkyl group is 1-bicyclo[2.2.2]octyl or 1-norbornyl, indicate that they behave like the 1-adamantyl derivative, although the reaction is less clean and slower for the small 1-norbornyl substituent. Some aspects of the chemistry of 2-(3-noradamantyl)adamantan-2-ol (**3-Norad**) have recently been reinvestigated; while the major products of its thermolysis are the rearranged alcohol, 1-hydroxy[1]diadamantane, and its fragmentation products, 2-(3-noradamantyl)-2,4-dehydroadamantane (**1-Norad**) can be detected in the early stages of the reaction.²²

EXPERIMENTAL

Alcohol synthesis. All alcohols were prepared by the one-step Barbier reaction of the appropriate 1-bromoalkane with 2-adamantanone in the presence of lithium in diethyl ether at -20°C , following the previously described procedure.²³ Products were purified by chromatography on alumina with light petroleum–diethyl ether mixtures as eluent, followed by crystallization from hexane.

2-(1-Adamantyl)adamantan-2-ol (3-Ad). Yield 52%; m.p. $217\text{--}218^\circ\text{C}$ (lit.,²⁴ $214\text{--}215^\circ\text{C}$; δ_{C} (ppm) (Bruker AC 200, CDCl_3), 26.9 (CH), 27.3 (CH), 29.2 (3 CH), 33.7 (2 CH), 34.9 (2 CH_2), 35.8 (2 CH_2), 37.3 (3 CH_2), 39.0 (3 CH_2), 39.5 (CH_2), 41.8 (C_q) and 77.0 (C—OH); IR (Perkin–Elmer 781, CCl_4 , ν_{OH}), 3622 cm^{-1} .

2-(1-Bicyclo[2.2.2]octyl)adamantan-2-ol (3-Oc). Yield 44%; m.p. $174\text{--}175^\circ\text{C}$; δ_{C} (ppm) (CDCl_3), 23.1 (CH), 26.1 (2 CH_2), 27.0 (CH), 27.3 (CH), 27.4 (2 CH_2), 34.2 (2 CH), 34.3 (2 CH_2), 35.6 (2 CH_2), 39.8 (CH_2), 39.9 (C_q) and 76.6 (in C_6D_6 , C—OH); IR (CCl_4 , ν_{OH}), 3623 cm^{-1} . Analysis: $\text{C}_{18}\text{H}_{26}\text{O}$ requires C 83.02, H, 10.84; found, C 82.7, H 11.0%.

2-(1-Norbornyl)adamantan-2-ol (**3-Norb**). Yield 56%; m.p. 106–107°C; δ_c (ppm) ($CDCl_3$), 26.9 (CH), 27.2 (CH), 29.4 (2 CH_2), 31.2 (2 CH_2), 34.57 (2 CH_2), 34.64 (2 CH_2), 35.3 (2 CH), 37.8 (CH), 38.9 (CH_2), 43.6 (CH_2), 55.9 (C_q) and 76.7 (C—OH); IR (CCl_4 , ν_{OH}) 3621 $^{-1}$. Analysis: $C_{17}H_{26}O$ requires C 82.87, H 10.64%; found, C 83.1, H 10.5%.

Dehydrobromination: 2-(1-Adamantyl)-2,4-dehydroadamantane (**1-Ad**) 2-(1-Adamantyl)adamantan-2-ol (**3-Ad**)²³ (0.1 g, 0.35 mmol) in benzene (2 cm³) at ca 0°C was stirred with oxalyl bromide (0.1 cm³) for 1 h. The solvent and excess oxalyl bromide were removed under vacuum and the residue was refluxed with pyridine (5 cm³) for 2 h. Chromatography on alumina yielded **1-Ad** (85 mg, 91%), m.p. 149–150°C (hexane); m/z (Finnigan MAT ITD 800B) 269, 268, 267, 136, 135 (100%), 133, 107, 93, 91 and 79; δ_c (ppm) ($CDCl_3$) (carbon type, J_{CH} in Hz), 20.2 (CH, 154), 24.2 (CH, 164), 26.3 (CH, 133), 28.6 (3 CH, 132), 29.4 (CH_2 , 127), 32.4 (CH, 137), 33.0 (CH_2 , 129), 33.2 (CH, 137), 33.2 (C_q), 34.2 (CH_2 , 124), 37.3 (3 CH_2 , 127), 39.0 (3 CH_2 , 127), 43.6 (C_q) and 50.3 (CH_2 , 127); δ_H (ppm) ($CDCl_3$), 1.25–2.0 (several br m, 26H), 2.20 (1H, m) and 2.32 (1H, m); IR (KBr), 751, 1030, 1063, 1101, 1340, 1445, 2842, 2900, 3002 and 3020 cm $^{-1}$. Analysis: $C_{20}H_{28}$ requires C 89.49, H 10.51; found, C 89.5, H 10.5%.

Similar treatment of 2-(1-bicyclo[2.2.2]octyl)-adamantan-2-ol (**3-Oc**) and 2-(1-norbornyl)adamantan-2-ol (**3-Norb**) gave the corresponding substituted 2,4-dehydroadamantanes, **1-Oc** and **1-Norb**, in yields of 93 and 48%, respectively. **1-Oc**: m.p. 89°C (hexane); m/z 243, 242 (100%), 241, 213, 199, 185, 135, 131, 117, 109, 105, 91, 81 and 79; δ_c (ppm) ($CDCl_3$), 21.0 (CH, J_{CH} = 155 Hz), 24.7 (CH, 134), 25.1 (CH, 169), 26.1 (3 CH_2), 26.2 (CH, 130), 27.6 (3 CH_2), 29.3 (CH_2), 31.5 (C_q), 32.5 (CH, 135), 33.0 (CH_2), 34.0 (CH_2), 34.0 (CH, 133), 42.0 (C_q) and 50.2 (CH_2); δ_H (ppm) ($CDCl_3$), 1.2–2.4 (several br m, 24H), 2.19 (m, 1H), 2.28 (m, 1H); IR (KBr), 758, 806, 1068, 1260, 1330, 1338, 1450, 2845, 2920, 3005 and 3018 cm $^{-1}$. Analysis: $C_{18}H_{26}$ requires C 89.19; H 10.81; found C 88.8, H 10.9%. **1-Norb**: oil, ca 96% pure containing inseparable impurity; m/z 229, 228 (100%), 227, 199, 185, 171, 157, 145, 143, 131, 129, 117, 105, 95, 93, 91, 81 and 79; δ_c (ppm) ($CDCl_3$), 24.3 (CH, J_{CH} = 155 Hz), 26.4 (CH, 132), 27.1 (CH, 164), 29.3 (CH_2), 30.7 (CH_2), 30.7 (CH_2), 32.6 (CH_2), 32.8 (CH, 134), 32.9 (CH_2), 33.0 (CH_2), 33.7 (CH_2), 35.4 (CH, 134), 36.3 (CH, 140), 38.5 (C_q), 39.6 (CH_2), 50.4 (CH_2) and 50.6 (C_q); δ_H (ppm) ($CDCl_3$), 1.2–1.9 (several br m, 22H), 2.09 (m, 1H), 2.21 (m, 1H); IR (KBr), 1026, 1067, 1099, 1323, 1341, 1454, 2850, 2862, 2940, 2999 and 3010 cm $^{-1}$.

Dehydration: thermolysis of 2-(1-Adamantyl)-adamantan-2-ol (**3-Ad**). 2-(1-Adamantyl)adamantan-2-ol (0.286 g, 1 mmol) was sealed under vacuum in a

thick-walled tube and heated at 280°C for 3 h. After cooling, the tube was carefully opened and the products were separated by chromatography on alumina to give residual alcohol (15 mg, 5%) and 2-(1-adamantyl)-2,4-dehydroadamantane (**1-Ad**) (0.243 g, 91%).

In the same way, 2-(1-bicyclo[2.2.2]octyl)-2,4-dehydroadamantane (**1-Oc**) and 2-(1-norbornyl)-2,4-dehydroadamantane (**1-Norb**) were obtained from the corresponding alcohols in yields of 94% (277°C, 5 h) and 46% (285°C, 5 h), respectively.

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