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HYDRIDE TRANSFER REACTIONS OF THE ADAMANTYL CATION—II

SYNTHESIS OF 1,3- AND 1,4-DISUBSTITUTED ADAMANTANES

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Abstract—Disproportionation reactions of 1- and 2-hydroxyadamantane, involving the hydride transfer of bridgehead hydrogens, are reported. These reactions can be used to prepare 1,3- and 1,4-dihydroxyadamantane. A number of new 1,4-disubstituted adamantanes are described and their stereochemical structure is elucidated.

IN THE preceding paper[1] we reported an intermolecular hydride transfer reaction of 2-hydroxyadamantane with the adamantyl cation, involving the exchange of the α-hydrogen of the alcohol. 2-Hydroxyadamantane can thus be disproportionated into adamantanone and adamantane.

We now wish to report on hydride transfer reactions of bridgehead hydrogens of both 1- and 2-hydroxyadamantane with adamantyl cations, esulting in the formation of respectively 1,3- or 1,4-dihydroxyadamantane (Figs. 1 and 2). It is necessary to adjust the reaction conditions carefully, since the course of the reaction is greatly influenced by the temperature and the acidity of the medium. This has been pointed out in the previous publication and will again be demonstrated in the present paper. Although these reactions may be carried out under a variety of acidic conditions,* 60–75% sulphuric acid generally proved a suitable medium for the synthesis of 1,3-dihydroxyadamantane from 1-hydroxyadamantane, and of 1,4-dihydroxyadamantane from 2-hydroxyadamantane.

1. *Disproportionation of 1-hydroxyadamantane into adamantane and 1,3-dihydroxyadamantane*

Upon treatment of 1-hydroxyadamantane with 70% sulphuric acid equimolar amounts of adamantane and 1,3-dihydroxyadamantane could be isolated. The total yield was 95%, based on converted 1-hydroxyadamantane. The identity of the 1,3-dihydroxyadamantane was proved by comparison of its IR spectrum with that of a sample prepared according to the method described by Stetter and Wulff.[2]

This experimental result indicates the formation of 1,3-dihydroxyadamantane to be due to disproportionation of 1-hydroxyadamantane.[3] We suggest a mechanism involving the initial esterification of the alcohol by the sulphuric acid, followed by an intermolecular hydride transfer of a bridgehead hydrogen. The 1-adamantyl

* Phosphoric acid and perchloric acid can also be used, as well as mixtures of sulphuric acid with phosphoric, acetic, or propionic acid. Moreover Lewis acids were found to be effective in disproportionating 1- and 2-hydroxyadamantane if used in an appropriate solvent, for instance BF_3 in acetic acid.

cation, generated either from the alcohol or its sulphuric acid ester, acts as the hydride acceptor and is transformed into adamantane. The reaction scheme is represented by Fig. 1.

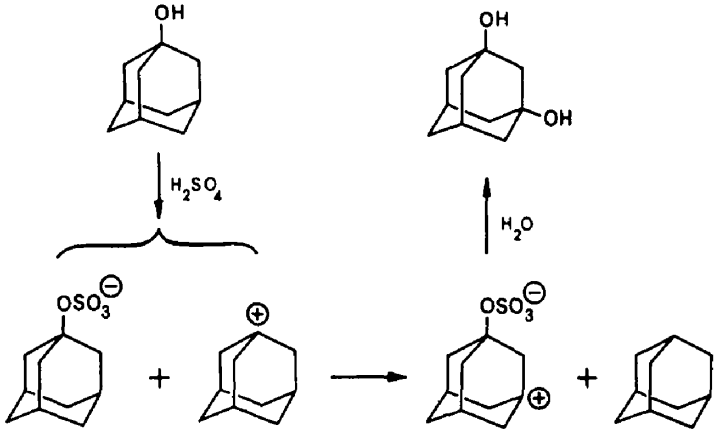


FIG. 1.

The assumption that adamant-1-yl hydrogen sulphate—in fact its anion—participates in the disproportionation reaction rather than 1-hydroxyadamantane is based on the results of an investigation into the effect of the sulphuric acid concentration on the reaction rate. It proved too difficult to determine the exact rate since competitive reactions, especially the 1,2-hydride shift of the 1-adamantyl cation, took place. Nevertheless the amount of 1,3-dihydroxyadamantane formed in sulphuric acid of different strengths could be estimated by a rough calculation.* Table 1 shows an initial increase in the rate of 1,3-dihydroxyadamantane formation towards higher acid strengths, i.e. from 70 to 85%. At acid concentrations of more than 90%, however, there was a decrease which was greater than could be explained by the occurrence of competitive reactions at these acid strengths.

A considerable inductive influence of bridgehead C-atoms in adamantane is well established.[4, 5] It therefore seems plausible that the hydride ion abstraction is facilitated by a sulphate anion located at another bridgehead carbon. Towards higher sulphuric acid concentrations the anion concentration would be lowered, and this would tend to retard the reaction.

* We considered the adamantane formation to be a measure of the sum of the rates of three disproportionation reactions. The contribution of one of them, i.e. the adamantanone-forming disproportionation,[1] was eliminated in the calculation. Another disproportionation via 2-hydroxyadamantane (see Section 2 of this paper) was neglected. However, with this last-mentioned disproportionation taken into account, the calculated values for 1,3-dihydroxyadamantane, reported in Table 1, would be lower still at sulphuric acid concentrations of more than 90%, because the formation of 1,4-dihydroxyadamantane is considered to be sufficiently rapid only in that case. In order to exclude the remote possibility that 1,3-dihydroxyadamantane could be transformed into adamantanone in more concentrated sulphuric acid, we treated this diol with 96% sulphuric acid under various reaction conditions. In none of these experiments was adamantanone found.

TABLE 1. DISPROPORTIONATION OF 1-HYDROXYADAMANTANE (0·8M) IN SULPHURIC ACID OF DIFFERENT STRENGTH

Sulphuric acid concentration %	Mol %* of 1,3-dihydroxyadamantane after 10 min at 75°C %
50	0
70	1·5
75	6·5
85	20
92	16
96	12

* Based on initial 1-hydroxyadamantane.

A disproportionation reaction of 1-adamantaneacetic acid into adamantane and 1,3-adamantanediacetic acid has been reported by Bott and Hellmann.[6,7] A mechanism involving the hydride abstraction from the 1-adamantaneacetic acid molecule has been suggested. Under the reaction conditions cited, however, adamant-1-yl sulphate could be formed, and subsequently this would participate in a disproportionation reaction identical with that described above. This would also account for the formation of a 1,3-disubstituted adamantane.

2. *Disproportionation of 2-hydroxyadamantane into adamantane and 1,4-dihydroxyadamantane*

On treatment of 2-hydroxyadamantane with 70% sulphuric acid, two different disproportionation reactions could be distinguished. One of them, leading to adamantanone and adamantane, has already been reported.[1] The other disproportionation was due to the transfer of a bridgehead hydrogen of 2-hydroxyadamantane; it led to the formation of a new dihydroxyadamantane and again adamantane, as indicated in Fig. 2. The new diol was obtained in a crystalline state but proved to consist of a mixture of two isomers.

Different isomers were to be expected, of course. From the fact that 2-hydroxyadamantane is not converted into 1-hydroxyadamantane in 70% sulphuric acid[1] we concluded that one of the OH groups of the diol must be at its original secondary place. Furthermore it could be supposed that the OH group resulting from the disproportionation would be located at a tertiary carbon, due to the preference of a bridgehead hydrogen to be split off as a hydride ion. Consequently 1,2- and 1,4-disubstituted adamantanes were to be expected.

Upon oxidation of the diols with chromic acid only one hydroxyketone was obtained, in nearly quantitative yield, confirming the presence of a secondary and of a tertiary OH group in the starting diol mixture.

The NMR spectrum of the hydroxyketone showed two protons α to the CO group. In the IR spectrum no intramolecular hydrogen-bonding could be detected.

These data excluded the presence of a 1,2-disubstituted adamantane derivative, and therefore we must be dealing with 1-hydroxyadamantan-4-one.

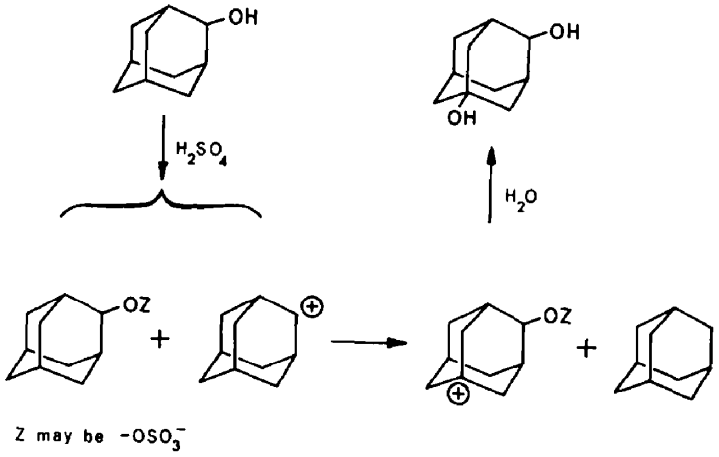


FIG. 2.

The NMR spectrum of the diol mixture showed two separate signals (ratio 1:2) for the proton α to the secondary OH group. These signals must be attributed to the presence of both the possible 1,4-isomers. After reduction of the hydroxyketone with LAH, both isomers of the 1,4-diol were again obtained, but in a different ratio (4:3).

The isolation and purification of the 1,4-dihydroxyadamantanes after disproportionation of 2-hydroxyadamantane merits some further specification. The diol fraction obtained by extraction of the quenched reaction mixture with chloroform proved to be contaminated with 1-hydroxyadamantan-4-one, apparently due to subsequent reaction (disproportionation) of one, or both, of the 1,4-diols. Though the hydroxyketone could be separated quite well by fractional crystallization or by chromatography, it proved easier to convert this contaminating ketone back into the diol by LAH reduction or to convert the mixture as a whole into the hydroxyketone by chromic acid oxidation.

On the other hand most of the 1,4-diol mixture was found in the aqueous layer as sulphuric acid esters. Hydrolysis of the esters by dilute (normal) acid appeared to be difficult, indicating the presence of the sulphate of a secondary alcohol. Heating with 40% sulphuric acid for several hours effected complete hydrolysis of the sulphates. Isolation, however, of the 1,4-diols from the aqueous solution remained rather laborious, owing to the solubility of these compounds in water. The oxidation of the diols to the hydroxyketone by chromic acid, immediately following the hydrolysis of the sulphates, was therefore preferred.

The organic sulphates could also be isolated from the aqueous solution upon neutralization with NaOH, evaporation of the water, and extraction of the dried salty residue with methanol. Purification and characterization, however, proved to be possible only after the sodium salt had been transformed into the S-benzylisothiouronium salt. The structure of this salt could be established by NMR and elemental analysis. We found 1-hydroxyadamant-4-yl sulphate as the anion.

3. *Synthesis of* 1,4-*disubstituted adamantanes*

From the 1,4-diol mixture or the hydroxyketone other 1,4-disubstituted adamantane derivatives were prepared. They are schematically indicated in Fig. 3. By treatment with $SOCl_2$ the 1,4-diol isomers were converted into a mixture of the two

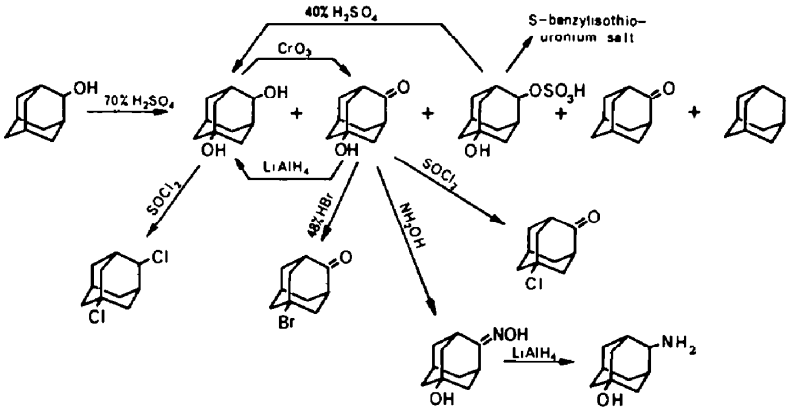


FIG. 3.

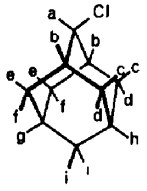
1,4-dichlorides, the structure of which could be established by NMR. We used the substituent shift data of 1- and 2-chloroadamantane,[8,9] assuming that the chemical shift additivity rule would hold for the 1,2- and 1,4-disubstitution pattern of adamantane. The 1,2-dichloro compound could be excluded on account of the great difference between the measured and the calculated resonance frequency of the proton α to the secondary chlorine.* From the values of the secondary protons, calculated for the two 1,4-dichloro compounds and given in Table 2, we concluded—in particular from protons C—that the main component must have its Cl-atoms in the 1,4-axial position, whereas the minor component has the 1,4-equatorial position. We are not certain whether the main isomer of the dichlorides correspond with that of the starting diols, because $SOCl_2$ can cause a change in the isomer ratio. The substituent shifts due to the OH groups are too small to allow of accurate establishment of the configuration of the original 1,4-dihydroxyadamantane isomers by a similar calculation.

A simple method for obtaining the 1,4-dichloroadamantanes directly after disproportionation of 2-hydroxyadamantane consisted in the addition of concentrated hydrochloric acid to the quenched reaction mixture, followed by slow distillation. The dichlorides, being volatile in water vapour, separated as a white waxy solid in the condenser.

* In 2-chloroadamantane the α-H was found at δ 4·39.[8,9] Introduction of a second Cl-atom on a neighbouring tertiary carbon would shift this signal 0·33 ppm downfield. The α-H in 1,2-dichloroadamantane should therefore be expected at δ 4·72. We found only signals at δ 4·33 and 4·23 (intensity ratio 1:3). If the second Cl-atom is introduced at an opposite tertiary carbon, giving 1,4-disubstitution, the α-H signal should be near δ 4·31, due to an upfield shift of 0·08 ppm. This agrees quite well with the experimental values. The double peak can thus be attributed to the two possible 1,4-isomers.

1-Hydroxyadamantan-4-one oxime was prepared from the hydroxyketone by reaction with hydroxylamine in aqueous alcohol. Reduction of the oxime with LAH in tetrahydrofuran yielded 4-aminoadamantan-1-ol as a mixture of both of the isomers

TABLE 2. δ-VALUES OF THE SECONDARY PROTONS IN 1,4-DICHLOROADAMANTANE. CALCULATIONS BASED ON δ-VALUES OF 2-CHLOROADAMATANE, USING SUBSTITUENT SHIFTS OF 1-CHLOROADAMANTANE: $\beta = 0{\cdot}33$, $\gamma = 0{\cdot}23$, $\delta = 0{\cdot}08$.[8,9]



Proton	2-Chloro-adamantane	Calc for 1,4-axial (h = Cl)	Found for main comp	Calc for 1,4-equatorial (g = Cl)	Found for minor comp
a	4·39	4·31	4·23	4·31	4·33
c	2·27	2·60	2·66	2·19	
d	1·57	1·90		1·49	1·50
e, f	1·86	1·78	1·82	2·19	
i	1·76	2·09	2·13	2·09	2·13

(ratio 1:1). 1-Chloroadamantan-4-one was obtained from the hydroxyketone after reaction with $SOCl_2$. 1-Bromoadamantan-4-one was obtained after boiling the hydroxyketone with concentrated hydrobromic acid.

EXPERIMENTAL

Conditions and details of measurements of m.ps, mass spectral data, IR absorption, and NMR have been reported in the preceding paper.[1] GLC was carried out on an F & M model 700, fitted with a 6 ft, $\varnothing$ $\frac{1}{8}$ in stainless steel column, filled with 80/100 mesh Chromosorb Waw, silanized with DDS and impregnated with 10% Apiezon L, at 175° with FID.

1,3-Dihydroxyadamantane. 1-Hydroxyadamantane (3·05 g) was added to 70% H_2SO_4 (25 ml) and stirred at 85° for 3 hr. After pouring the mixture on ice, adamantane (39%) and unchanged starting material (19%) were removed by ether extraction. The yields were established by GLC. The aqueous layer was heated on the steam bath for 2 hr. After cooling and the addition of ice, the soln was neutralized with 50% NaOH, saturated with NaCl, and extracted several times with n-BuOH. The extracts were combined, dried over Na_2SO_4, filtered, and evaporated to dryness. 1,3-Dihydroxyadamantane (1·36 g) was obtained as a white solid residue. GLC analysis revealed a purity of 93%, yield 94%, based on disproportionated 1-hydroxyadamantane. The substance was purified by sublimation (at 160° *in vacuo*) and subsequent crystallization from EtOAc–EtOH (9:1). Colourless crystals (0·97 g, recovery 78%), m.p. 325–330°. (Found:* C, 71·2; H, 9·6; O, 19·2. Calc. for $C_{10}H_{16}O_2$: C, 71·4; H, 9·6; O, 19·0%). The 1,3-dihydroxyadamantane that we prepared by hydrolysis of 1,3-dibromoadamantane melted at 333–336° (lit. 315°[2]). The IR spectra were identical; IR (KBr): 3250 (s) (OH), 2925 (s) and 2850 (m) (CH), 1300 (m), 1204 (m), 1136 (s), 1111 (m), 1030 (s), 947 (m), 912 (m), and 555 (m) cm^{-1}. NMR ($CDCl_3$–DMSO 1:1): δ 4·35 (2H)

* Elemental micro analyses were done by A. Bernhardt, Micro Analytical Lab., Max-Planck-Institut für Kohlenforschung, Mülheim, (W. Germany).

(OH), 2·16 (2H) (tertiary protons), 1·42 (2H) (protons at C-6), 1·54 and 1·50 (10H) (remaining secondary protons).

1-Hydroxyadamantan-4-one. 2-Hydroxyadamantane* (6·1 g) was added to 70% H_2SO_4 (50 ml) and stirred at 90° for 2½ hr. The mixture was poured on ice, neutralized with 50% NaOH, and extracted twice with ether. The extracts were combined and washed with water. The ether solution was dried over Na_2SO_4, filtered, and evaporated to dryness. A white solid residue (4·32 g) resulted. The substance was analysed by GLC. We found adamantane (44·5%), adamantanone (17·5%), and unchanged 2-hydroxyadamantane (5%). The yields were based on initial 2-hydroxyadamantane. The aqueous layer was subsequently extracted 4 times with chloroform. The extracts were combined, washed with 10% NaCl, dried over Na_2SO_4, and evaporated to dryness, resulting in a white solid residue (1·15 g). GLC analysis revealed 1,4-dihydroxyadamantane (2 components) and 1-hydroxyadamantan-4-one. The yields, based again on initial 2-hydroxyadamantane, were 9·5% for the diols and 4·5% for the hydroxyketone. This mixture was dissolved in 0·5N H_2SO_4 (25 ml) and acetone (10 ml), CrO_3 (1·0 g) was added and the soln was warmed on the steam bath for 1 hr. After evaporation of the acetone and dilution with water (20 ml) the mixture was extracted twice with chloroform. The extracts were combined, washed with 10% NaCl, dried over Na_2SO_4, treated with charcoal, filtered, and evaporated to dryness. A white solid residue (0·86 g) was obtained, m.p. 315–321°. GLC analysis yielded 1-hydroxyadamantan-4-one of at least 98% purity, in 25% of the theoretical amount, based on disproportionation of 2-hydroxyadamantane. After crystallization from CCl_4 (recovery 76%) the m.p. rose to 319–322°. (Found: C, 72·2; H, 8·5; O, 19·4. $C_{10}H_{14}O_2$ requires: C, 72·3; H, 8·5; O, 19·3%; mass of molecular ion: Found, 166·0994; Calc. for $C_{10}H_{14}O_2$, 166·0994); NMR: δ 2·62 (2H) (protons α to the C=O group), 2·35 (1H) (tertiary proton at C-7), 1·98 (10H) (secondary protons), 1·89 (1H) (OH); IR (CH_2Cl_2): 3590 (m) (free OH), 2920 (s) and 2855 (m) (CH), 1720 (vs) (C=O), 1110 (s), 1090 (m), 1066 (m), 1055 (s), 971 (m), and 926 (s) cm^{-1}. The total yield of isolated 1,4-disubstituted product is 40% including the 1,4-dihydroxyadamantane still present in the aqueous layer as its sulphuric acid ester (see below), and based on disproportionation of 2-hydroxyadamantane.

S-Benzylisothiouronium 1-hydroxyadamant-4-yl sulphate. After disproportionation of 2-hydroxyadamantane (6·1 g) as described above and extraction of the quenched and neutralized reaction mixture with ether and chloroform, the aqueous layer was concentrated *in vacuo* to dryness. The dried salty residue was extracted several times with hot MeOH. The extracts were combined, filtered and evaporated to dryness. An extremely hygroscopic foamy residue (1·14 g) was obtained. The substance was dissolved in hot water (3 ml) and added to a hot soln of S-benzylisothiouronium chloride (1·0 g) in water (3 ml). Colourless crystals separated on cooling. They were collected the next day, washed with cold water and dried *in vacuo* over P_2O_5, m.p. 193–196°, yield 1·25 g, which is 15% of the theoretical amount, based on disproportionation of initial 2-hydroxyadamantane. (Found: C, 52·2; H, 6·2; O, 19·4; N, 6·7; S, 15·3. $C_{18}H_{26}O_5N_2S_2$ requires: C, 52·2; H, 6·3; O, 19·3; N, 6·8; S, 15·5%); NMR (TFA): δ 7·8–7·2(NH and aromatic protons), 4·87 (½H), 4·76 (½H) (proton α to the $-OSO_3^-$ group of both the isomers), 4·44 (2H) (CH_2 of the benzyl group), 2·56 (3H) (tertiary protons), 1·5–2·4 (10H) (remaining secondary adamantane protons); IR (KBr): 3280 (s) (OH), 3075 (s) (NH), 2930 (s) and 2860 (m) (CH), 1665 (s) (C=N), 1250 (s), 1180 (s) ($-SO_4^-$), 1110 (m), 1050 (s), 980 (s), 940 (s), 918 (m), 855 (m), and 825 (m) cm^{-1}.

1,4-Dihydroxyadamantane. 1-Hydroxyadamantan-4-one (2·6 g) was added to a soln of LAH (1·3 g) in ether (50 ml). The mixture was stirred at room temp for 3 hr, water (5 ml) was added, the solvents were removed by evaporation under reduced press, and the dry residue was extracted 3 times with boiling chloroform. The extracts were filtered; the filtrates were combined and evaporated to dryness. A white solid residue (2·4 g, yield 90%) resulted. The substance was crystallized from EtOAc (recovery 80%), m.p. 327–331°. (Found: C, 71·5; H, 9·6; O, 19·2. $C_{10}H_{16}O_2$ requires: C, 71·4; H, 9·6; O, 19·0% mass of molecular ion: Found, 168·1142; Calc. for $C_{10}H_{16}O_2$, 168·1150); NMR ($CDCl_3$ + DMSO): δ 3·81 (½H) and 3·74 (½H) (proton α to the sec OH group of both the isomers), 3·33 (2H) (OH), 2·2–1·2 (10H) (remaining adamantane protons); IR (CH_2Cl_2: 3595 (m) (free OH), 2915 (s) and 2855 (m) (CH), 1110 (s), 1094 (m), 1039 (s), 1029 (sh), 953 (m) cm^{-1}.

* 2-Hydroxyadamantane can easily be obtained by the slightly modified method of von R. Schleyer and Nicholas.[10] To adamantanone (30·0 g) dissolved in ether (300 ml) a soln of LAH (7·3 g) in ether (150 ml) was added. The mixture was stirred at room temperature for 2 hr. The complex was decomposed with water. Precipitated hydroxides were dissolved by the addition of hydrochloric acid. The ether layer was separated. The aqueous layer was extracted with CH_2Cl_2. The extracts were combined, washed with water, and dried over Na_2SO_4. After evaporation of the solvents a quantitative yield of pure 2-hydroxyadamantane (30·0 g, colourless crystals, m.p. 296–299°) was obtained. Lit. m.p. 296·2–297·7.[10]

1,4-Dichloroadamantane. 1,4-Dihydroxyadamantane (1·0 g, isomer ratio 4:3) was dissolved in $SOCl_2$ (10 ml) and boiled under reflux for 5 hr. The mixture was concentrated *in vacuo* to dryness, MeOH was added, and after evaporation of the solvent the residue was sublimed at 100° and 15 mm Hg, colourless crystals (1·1 g, yield 90%) were obtained, m.p. 148–151°. (Found: C, 58·9; H, 6·8; Cl, 34·5. $C_{10}H_{14}Cl_2$ requires: C, 58·6; H, 6·9; Cl, 34·6%; mass of molecular ion: Found: 204·0472; Calc. for $C_{10}H_{14}Cl_2$, 204·0472); GLC: 2 separate peaks, area ratio 1:2. NMR: δ 4·33 ($\frac{1}{3}$H) and 4·23 ($\frac{2}{3}$H) (proton α to the sec Cl), other resonance frequencies have been reported in Table 2; IR (KBr): 2930 (s) and 2860 (m) (CH), 1100 (m), 1028 (s), 944 (m), 921 (m), 831 (s), 822 (m), 787 (m), 765 (m), 660 (m), 495 (m), 461 (m), and 410 (m) cm^{-1}. Treatment of the 1,4-diols in an isomer ratio of 1:2 with $SOCl_2$ under the same reaction conditions yielded the 1,4-dichlorides in a ratio of 1:3.

1-Chloroadamantan-4-one: 1-Hydroxyadamantan-4-one (2·00 g) was dissolved in $SOCl_2$ (12 ml) and boiled under reflux for 2 hr. The mixture was evaporated to dryness. The residue was dissolved in CH_2Cl_2 and washed with 0·5N NaOH and 10% NaCl aq. The organic layer was dried over Na_2SO_4 and evaporated to dryness. The white solid residue (2·24 g) was crystallized from pet ether (10 ml, b.p. 60–80°). A small insoluble fraction (0·12 g) was separated by filtration. Colourless crystals (1·45 g) were obtained, m.p. 197–200°. A second fraction (0·31 g, m.p. 199–202°) crystallized after concentration of the mother liquor, yield 79%. (Found: C, 64·8; H, 7·3; O, 8·8; Cl, 19·4. $C_{10}H_{13}OCl$ requires: C, 65·0; H, 7·1; O, 8·7; Cl, 19·2%; mass of molecular ion: Found, 184·0654; Calc. for $C_{10}H_{13}OCl$, 184·0655); NMR: δ 2·62 (2H) (protons α to the C=O group), 2·36 (7H) (protons at C-2, C-7, C-8, and C-9), 2·00 (4H) (protons at C-6 and C-10); IR (KBr): 2935 (s) and 2860 (m) (CH), 1725 (vs) (C=O, with 5 side peaks or shoulders as in adamantanone), 1289 (m), 1060 (s), 1024 (s), 829 (s), 664 (m), 473 (m) cm^{-1}.

1-Hydroxyadamantan-4-one oxime. 1-Hydroxyadamantan-4-one (1·50 g) was dissolved in EtOH (10 ml) and added to a soln of hydroxylamine hydrochloride (1·0 g) in 1N NaOH (8 ml). The mixture was warmed on the steam bath. The EtOH was allowed to evaporate. After a reaction period of 1 hr, water (5 ml) was added, the soln was saturated with NaCl and extracted 3 times with hot chloroform. The extracts were combined, dried over Na_2SO_4, and evaporated to dryness. A sticky solid (1·70 g) resulted. Crystallization from EtOAc gave colourless crystals (1·17 g), m.p. 157–160°. After concentration of the mother liquor a second crop of crystals was obtained (0·33 g), m.p. 152–155°, yield 92%. (Found: C, 66·4; H, 8·5; O, 17·6; N, 7·6. $C_{10}H_{15}O_2N$ requires: C, 66·3; H, 8·3; O, 17·7; N, 7·7%); NMR ($CDCl_3$ + DMSO): 3·78 (1H) (proton α and syn to the =NOH group), 3·22 (1H) (=NOH), 2·69 (1H) (proton α and anti to the =NOH group), 2·24 (1H) (tertiary proton), 1·9–1·7 (10H) (remaining secondary adamantane protons). Mass of molecular ion: Found, 181·1101; Calc. for $C_{10}H_{15}O_2N$, 181·1103. IR (KBr): 3300 (vs) (OH), 2925 (s) and 2855 (m) (CH), 1660 (w) (C=N), 1115 (s), 1095 (s), 1067 (m), 925 (s), and 848 (m) cm^{-1}.

4-Aminoadamantan-1-ol hydrochloride. LAH (0·20 g) was added to a soln of 1-hydroxyadamantan-4-one oxime (0·35 g) in THF (15 ml). The soln was stirred at 65° for 20 hr. After cooling of the reaction mixture water (0·8 ml) was added. The solvent was distilled off and the residue was extracted 3 times with boiling $CHCl_3$. The extracts were combined and evaporated to dryness. The sticky residue (0·31 g) was neutralized with dil HCl and washed with CH_2Cl_2. The aqueous soln was evaporated to dryness. The white solid residue (0·29 g) was crystallized twice from MeOH (with the addition of ether), yielding colourless crystals (0·12 g, yield 30%), m.p. 356–358°. Mass of molecular ion of the free base: Found, 167·1309; Calc. for $C_{10}H_{17}ON$, 167·1310; NMR (free base in $CDCl_3$): δ 2·90 ($\frac{1}{2}$H) and 3·03 ($\frac{1}{2}$H) (proton α to the NH_2 group), 2·2–1·4 (OH and remaining adamantane protons); IR (HCl salt in KBr): 3300 (m) (OH), 3020 (m) (NH), 2925 (s) and 2855 (m) (CH), 1600 (w), 1515 (m), and 1097 (m) cm^{-1}. (Found: C, 58·9; H, 8·7; O, 8·1; N, 7·0; Cl, 17·3. $C_{10}H_{18}ONCl$ requires: C, 58·9; H, 8·9; O, 7·9; N, 6·9; Cl, 17·4%).

1-Bromoadamantan-4-one. 1-Hydroxyadamantan-4-one (2·50 g) was dissolved in 48% HBr (25 ml) and boiled under reflux for 7 hr. The soln was diluted with water (25 ml) and extracted twice with ether. The extracts were combined and washed with 10% NaCl aq. The ether layer was dried over Na_2SO_4, filtered, and evaporated to dryness. A light yellow solid (2·68 g) resulted. Crystallization from pet. ether (b.p. 60–80°) gave colourless crystals (2·42 g, yield 70%), m.p. 150–154°. (Found: C, 53·2; H, 5·8; O, 7·0; Br, 34·1. $C_{10}H_{13}OBr$ requires: C, 52·4; H, 5·7; O, 7·0; Br, 34·9%); NMR: δ 2·56 (8H) (tertiary protons at C-3 and C-5; secondary protons at C-2, C-8, and C-9), 2·29 (1H) (tertiary proton at C-7), 2·05 (4H) (secondary protons at C-6 and C-10); IR (KBr): 2930 (s) and 2860 (m) (CH), 1730 (vs) (C=O, with five side peaks or shoulders as in adamantanone), 1060 (s), 1017 (s), 812 (s), 790 (s), 653 (m), 470 (m) cm^{-1}.

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