Tetrahedron. Vol. 28, pp. 4353 to 4356. Pergamon Press 1972. Printed in Great Britain

2-BROMO-4,7,7-TRIMETHYLTRICYCLO[2.2.1.0^{2,6}]-HEPTAN-3-ONE

CONFIGURATIONAL ANALYSIS OF 4,7,7-TRIMETHYLTRICYCLO-[2.2.1.0^{2,6}]HEPTAN-3-OLS USING Eu(DPM)^3

A. J. M. REUVERS, A. SINNEMA and H. VAN BEKKUM
Laboratorium voor Organische Chemie, Technische Hogeschool
Julianalaan 136, Delft-2208, The Netherlands

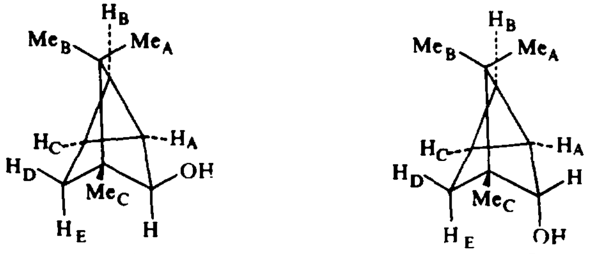
(*Received in the UK* 23 *February* 1972; *Accepted for publication* 12 *April* 1972)

Abstract—A tricyclic ketone was isolated from the reaction of α,α-dibromocamphor with $AgNO_3$. Reduction with LAH gave a tricyclic alcohol, which was identified by means of PMR spectroscopy as *endo*-4,7,7-trimethyltricyclo[2.2.1.0^{2,6}]heptan-3-ol. Literature data of this compound and its *exo*-isomer were conflicting. Using 100 MHz PMR spectroscopy and $Eu(DPM)_3$ we were able to assign the correct configuration to each isomer.

IN A previous publication[1] we communicated our findings on the acids formed in the reaction of α,α-dibromocamphor with $AgNO_3$ in boiling glacial acetic acid. We now report on the neutral products which have not previously been investigated.[2] Two major reaction products are formed: α-bromocamphor (10% yield) and a compound (15% yield) which was isolated by preparative GLC (I, m.p. 46–47°, from n-hexane). Mass spectral and combustional analysis gave the molecular formula: $C_{10}H_{13}BrO$. The IR spectrum (CCl_4) showed bands at 2965, 1780, 1460, 1370, 878, 870, and 840 cm^{-1}. The 100 MHz PMR spectrum (CD_3COCD_3) showed resonances at $\delta = 2{\cdot}40$ ppm (s, 2H), 2·06, 1·90 (AB-quartet, $J = 12{\cdot}0$ Hz, 2H), 0·98 (s, 3H), 0·94 (s, 3H), and 0·83 (s, 3H). From these data we concluded that I is a tricyclic ketone.

Reduction of I with LAH in THF specifically[3] yielded one alcohol (II, m.p. 174–175°). Mass spectral and combustional analysis gave as formula $C_{10}H_{16}O$. Spectroscopic data: IR (CCl_4): 3630, 3062, 2950, 2882, 1460, 1361, 1274, 1043 and 842 cm^{-1}; PMR (100 MHz, $CDCl_3$): $\delta = 3{\cdot}59$ ppm (s, 1H), 1·82 (s, 1H, disappears on addition of D_2O), 1·57, 1·46 (A-part of an AB-quartet, $J = 11{\cdot}0$ Hz, additionally split with $J = 1{\cdot}8$ Hz), 1·17–0·83 (mm, 4H), 1·11 (s, 3H), 0·86 (s, 3H), and 0·83 (s, 3H). Upon addition of $Eu(DPM)_3$ the complex multiplet ($\delta = 1{\cdot}17 - 0{\cdot}83$ ppm) resolved into 3 triplets ($J = 5{\cdot}0$ Hz) and the B-part of the AB-quartet. Irradiation of any of the 3 triplets changed the other two into doublets.

Our conclusion was that II is 4,7,7-trimethyltricyclo[2.2.1.0^{2,6}]heptan-3-ol. The 3 triplets originate from the 3 cyclopropane protons and the AB-quartet from the 2 C_5 hydrogens. One of these is long-range coupled ($J = 1{\cdot}8$ Hz) with the proton on C_3.[4] A literature survey showed that both 4,7,7-trimethyltricyclo[2.2.1.0^{2,6}]heptan-3-ols (see Fig) have been synthesized.[5] Spectral data for the isomer to which the *exo*-configuration was assigned have been given by Hanack *et al.*[6] (IR) and Antkowiak[7] (IR and PMR) and for the other isomer by Hanack[6] (IR), Mälkönen[8] (IR), and Crawley *et al.*[9] (PMR). A comparison of our IR data with the literature showed that



exo(II^A) *endo*(II^B)

Fig

the bands at 3062 and 842 cm^{-1} are in agreement with those given by Hanack for the isomer called *exo*-tricyclenol. The IR data of Antkowiak for the isomer which he named *exo*-isocyclenol resemble those for the isomer to which Hanack and Mälkönen assigned the *endo*-configuration. In view of these conflicting assignments we decided to settle the problem of the configurations with the help of PMR spectra and the influence of a paramagnetic shift reagent.[10]

Both 4,7,7-trimethyltricyclo[2.2.1.0^{2,6}]heptan-3-ols (II^A and II^B) were synthesized.[11] 100 MHz PMR spectra from CDCl$_3$ solutions were obtained while increasing amounts of Eu(DPM)$_3$ were added. The results are collected in Tables 1 and 2.

Table 1. PMR data of II^A

Mol. ratio[a]	δ-values (ppm, from internal TMS)								
	Me$_1^b$	Me$_2$	Me$_3$	t$_1^c$	t$_2$	t$_3$	A[d]	B[d]	H$_{C_3}$
0·00	1·14	0·87	0·85		1·25–0·90		1·50	~1·0	3.62
0·30	3·78	2·89	1·95	3·84	2·69	2·07	2·69	2·55	9.38
0·40	4·86	3·78	2·40	4·94	3·31	2·51	3·26	3·26	12·15
0·55	6·47	5·12	3·08	6·55	4·25	3·18	4·13	4·28	16·30
0·80	9·17	7·35	4·21	9·25	5·80	4·28	5·57	6·01	23·21
slope[e]	10·8	8·2	4·5	10·8	6·2	4·4	5·7	6·9	27·7

Table 2. PMR data of II^B

Mol. ratio[a]	δ-values (ppm, from internal TMS)								
	Me$_1^b$	Me$_2$	Me$_3$	t$_1^c$	t$_2$	t$_3$	A[d]	X[d]	H$_{C_3}$
0·00	0·83	0·80	0·80	1·19	1·19	1·19	1·58	1·43	3·86
0·30	4·03	2·10	1·95	5·09	3·68	2·76	7·35	4·23	10·90
0·40	4·94	2·47	2·35	6·14	4·33	3·22	8·80	4·94	13·23
0·55	6·31	3·03	2·95	7·72	5·30	3·92	10·97	6·00	16·73
0·80	8·59	3·96	3·96	10·34	6·92	5·08	14·58	7·77	22·57
slope[e]	9·1	3·7	4·0	10·5	6·5	4·6	14·5	7·1	23·3

[a] mmol Eu(DPM)$_3$: mmol II. [b] Me$_1$ = fastest shifting Me signal. [c] t$_1$ = fastest shifting triplet. [d] A,B = A-part or B-part of the AB-quartet of the C$_3$-protons in II^A; A,X = A-part or X-part of the signal of the C$_3$-protons (this signal is an AB-quartet, but upon addition of Eu(DPM)$_3$ it changes into an AX-system). [e] obtained by least squares.

The paramagnetic shifts induced by Eu(DPM)$_3$ are predominantly of the pseudocontact type and have therefore a $1/R^3$ dependency. However, R is difficult to define due to uncertainty in the conformational preferences of the Eu-complexed OH function. We have taken the distance between the OH oxygen atom and the proton(s) in question as decisive.[12] An examination of molecular models of *exo*- and *endo*-4,7,7-trimethyltricyclo[2.2.1.$0^{2,6}$]heptan-3-ol reveals that in the *exo*-isomer two Me groups are relatively close to the OH oxygen atom and in the *endo*-isomer only one. Furthermore in the *endo*-configuration one of the C_5-protons is close to the OH function. From these considerations and the data in Tables 1 and 2 the conclusion is that II^A is the *exo*-isomer and II^B the *endo*-alcohol.

The individual signals were tentatively assigned as follows. In *exo*-II Me_1 will be Me_A, because this Me group is somewhat closer to the OH oxygen atom than Me_C, which therefore must be Me_2, and the third Me signal (Me_3) is Me_B (cf the Me assignments in isoborneol on similar arguments, *e.g.*[13]). The cyclopropane protons can easily be assigned: $t_1 = H_A$, $t_2 = H_B$, and $t_3 = H_C$. A decision as to which part of the AB-system belongs to the *endo*- (or *exo*-) proton on C_5 is more difficult to make, since there is neither a big difference in slope nor in distance. The slower shifting A-part, however, is long-range coupled ($J = 1{\cdot}8$ Hz) with the *endo*-C_3-proton. This indicates that the A-part belongs to the *exo*-C_5-proton.[14] We assign therefore the A-part of the AB-quartet to H_D and the B-part to H_E. In the *endo*-isomer Me_1 clearly belongs to Me_C. For the other two Me signals we favour the assignment of Me_2 to Me_A and Me_3 to Me_B on a comparison with the Me signals of borneol.[13] Here the assignment of the cyclopropane protons is different, because H_C is closer to the oxygen atom than H_B, thus $t_1 = H_A$, $t_2 = H_C$, and $t_3 = H_B$. As already stated above the *endo*-C_5-proton (H_E) is much closer to the OH oxygen atom than H_D, therefore the fast shifting A-part of the AB-system belongs to H_E and the slower shifting B-part to H_D. No long-range coupling could be detected, but the signals of the C_5-protons and the C_3-proton are considerably broadened.

On account of the fact that the IR and PMR spectra of our tricyclic alcohol and those of *exo*-4,7,7-trimethyltricyclo[2.2.1.$0^{2,6}$]heptan-3-ol are identical and different from the *endo*-isomer we conclude that our alcohol and *exo*-II are the same. An examination of the literature data shows that Hanack,[6] Mälkönen,[8] and Crawley[9] correctly ascribed *exo*- and *endo*-configurations to the two isomeric alcohols, while the alcohol named *exo*-isocyclenol by Antkowiak[7] is identical to *endo*-4,7,7-trimethyltricyclo[2.2.1.$0^{2,6}$]heptan-3-ol.

The bromoketone isolated by us from the reaction of α,α-dibromocamphor and $AgNO_3$ in boiling AcOH must be 2-bromo-4,7,7-trimethyltricyclo[2.2.1.$0^{2,6}$]-heptan-3-one, if it is accepted that no skeletal change occurs during the reduction with LAH. The position of the bromine atom was inferred from the missing of one cyclopropane proton and the high CO frequency (1780 cm^{-1}). Brown *et al.*[15] reported for the CO frequency in tricyclo[2.2.1.$0^{2,6}$]heptan-3-one 1762 cm^{-1}. We assume that the ketone is produced *via* the abstraction of a bromide ion from α,α-dibromocamphor by a silver ion, followed by an internal cyclization of the resulting carbonium ion.

Acknowledgements—We thank Dr. W. Z. Antkowiak of the University of Poznán, Poland for a generous gift of isocyclenol, Dr. A. van Veen for useful discussions, Mr. T. A. van Vliet and Mr. G. K. van Rij for preliminary experiments, Mr. M. van Leeuwen for the elemental analyses, and Mr. J. M. van der Toorn for recording the PMR spectra on the Varian XL-100-15 spectrometer.

REFERENCES

[1] A. J. M. Reuvers, J. A. Jongejan, J. Klomp and H. van Bekkum, *Org. Prep. Proced. Int.* **3**, 83 (1971)

[2] A. Lapworth, *J. Chem. Soc.* **75**, 1134 (1899)

[3] M. N. Rerick in R. L. Augustine (Ed.), *Reduction*, p. 33, Dekker, New York (1968)

[4] J. M. Coxon, M. P. Hartshorn and A. J. Lewis, *Aust. J. Chem.* **24**, 1017 (1971)

[5] J. Bredt and W. Holz, *I. Prakt. Chem.* [2] **95**, 133 (1917); M. Lipp and N. Proth, *Ber. Dtsch. Chem. Ges.* **74B**, 1 (1941); M. Lipp, E. Oeckinghaus and C. L. Conze, *Ibid.* **74B**, 6 (1941); M. Lipp, Naturforschung und Medizin in Deutschland (Edited S. K. Ziegler), Bd 36 *Präparative Organische Chemie*, Tl 1, p. 236–7, DVB, Wiesbaden (1948)

[6] M. Hanack and H. Eggensperger, *Ann.* **648**, 1 (1961)

[7] W. Z. Antkowiak, *Bull. Acad. Pol. Sci., Ser. Sci. Chim.* **14**, 517 (1966)

[8] P. Mälkönen, *Ann. Acad. Sci. Fennicae* (A2), 1964, No. 128, 22

[9] J. K. Crandall, L. C. Crawley, D. B. Banks and L. C. Lin, *J. Org. Chem.* **36**, 510 (1971)

[10] J. Paasivirta, *Suomen Kemistilehti* **B44**, 135 (1971)

[11] M. Hanack and H. Eggensperger, *Ann.* **648**, 3 (1961)

[12] P. V. Demarco, T. K. Elzey, R. B. Lewis and E. Wenkert, *J. Am. Chem. Soc.* **92**, 5734 (1970)

[13] K. Tori, Y. Yoshimura and R. Muneyuki, *Tetrahedron Letters*, 333 (1971)

[14] L. M. Jackman and S. Sternhell, *Applications of Nuclear Magnetic Resonance Spectroscopy in Organic Chemistry* (2nd Ed.), p. 334, Pergamon Press, Oxford (1969)

[15] H. C. Brown and J. Muzzio, *J. Am. Chem. Soc.* **88**, 2811 (1966)