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ACETOLYSIS OF 2,3-*EXO*-DIMETHYLENE-*ANTI*-7-NORBORNYL BROSYLATE. ASSISTANCE OF A CONJUGATED DIENE

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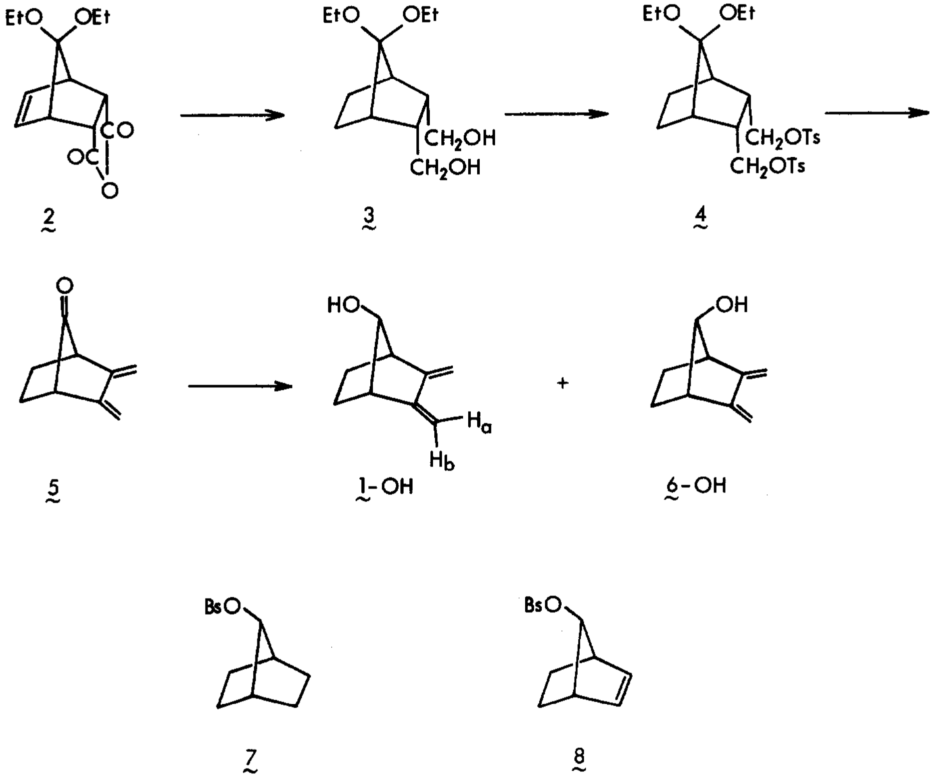
The role of a neighboring π-group in solvolysis has been the topic of recent reports and *anti*-7-norbornenyl derivatives are among the model compounds most extensively investigated.[1] This paper describes the acetolysis of 2,3-*exo*-dimethylene-*anti*-7-norbornyl brosylate (**1**-OBs), possessing a conjugated diene system at the back side to the leaving brosyloxy group.

The synthesis of **1** was modelled after those of Bailey[2a] and Bowe[2b] and their coworkers as shown in Chart 1. The adduct (**2**) obtained from cyclopentadienone diethyl ketal and maleic anhydride[3] was converted to the saturated diol (**3**), bp 150-153° (0.6 mm), $n^{23}D$ 1.4890, by catalytic reduction followed by $LiAlH_4$ reduction in THF. Esterification of **3** with 2 mol of tosyl chloride in pyridine (the ditosylate **4**, mp 105-107°) followed by elimination with potassium *tert*-butoxide in dimethylsulfoxide and hydrolysis in 70% aqueous acetic acid provided the ketone **5**, bp 80° (3 mm), $\nu_{C=O}^{CCl_4}$ 1786.5 cm^{-1}. Sodium borohydride reduction of **5** afforded a 3 : 2 mixture of epimeric alcohols, readily separable by preparative tlc using a mixed solution of n-hexane and ether (8 : 5) as developing solvent. The minor alcohol of 2 parts, mp 82-83°, was assigned as the syn alcohol **6**-OH on the basis of strong intramolecular OH$\cdots\pi$ absorption[4] appearing at 3582 cm^{-1} in the infrared spectrum [uv max (EtOH) 247.5 mμ (ε 8970); nmr (CCl_4) δ 1.1-1.9 (m, 4H, CH_2-CH_2), 2.55 (q, 2H, bridgeheads), 3.83 (broad s, 1H, C$\underline{H}$-OH), 4.90 (s, 2H, H_b in *exo*-methylene), and 5.30 (s, 2H, H_a in *exo*-methylene)]. The main alcohol of 3 parts, mp 38-39°, was assigned as the anti **1**-OH [uv max (EtOH) 250.5 mμ (ε 9120); nmr (CCl_4) δ 1.13-2.22 (m, 4H, CH_2-CH_2), 2.55 (q, 2H, bridgeheads), 3.87 (broad s, 1H, C$\underline{H}$-OH), 4.72 (s, 2H, H_b in *exo*-methylene) and 5.08 (s, 2H, H_a in *exo*-methylene)]. These alcohols were transformed into the brosylate esters, **1**-OBs, mp 76-78°, and **6**-OBs, mp 120-121°

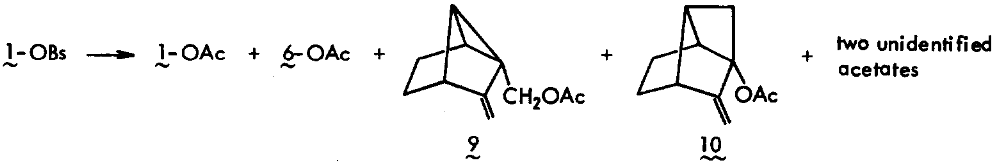
Chart 1



The solvolyses of 1-OBs and 6-OBs were carried out in glacial acetic acid buffered with sodium acetate. Clean first order kinetics was obtained with 1-OBs, while under the same conditions 6-OBs underwent a complicate decomposition for which rate measurement was not possible. The rate data for 1-OBs are listed in Table I together with corresponding data for 7-norbornyl brosylate (7)[5] and *anti*-7-norbornenyl brosylate (8)[6] for comparison.

Under the reaction conditions used in the kinetic runs (140°, ten-half lives), the acetolysis of 1-OBs produced the retained 1-OAc in 53% yield, the inverted 6-OAc in ~0.1%, a 1 : 1 mixture of two rearranged acetates (9 and 10) in 40%, and two acetates of unknown structures in about 7% yield (by vpc).

The nmr spectrum of the mixture of 9 and 10 (in $CDCl_3$) showed two protons due to one *exo*-methylene as a multiplet at δ 4.5-4.7, and a broad singlet at δ 4.39 assignable to two protons attached to the



9

10

carbon bearing the acetoxyl group of 9. The mass spectrum of the mixture showed the parent peak at mass number 178 the same as for 1-OAc. The structures of 9 and 10 were tentatively assigned on the basis of these spectral data.

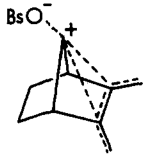
Table I. Acetolysis Rates of Various 7-Norbornyl Brosylates

Compd No.	Temp, °C	Rate, sec^{-1}	Calcd at 25.0° $\Delta H^{\ddagger}$ kcal/mol	$\Delta S^{\ddagger}$ eu
1-OBs	140.0	4.59×10^{-5}		
	165.0	2.29×10^{-4}		
	(25)[a]	8.77×10^{-10}	22.5	-24
7	(25)[a,b]	6.16×10^{-14}	34.6	-2.8
8	(25)[a,c]	2.6×10^{-3}	23.3[d]	5.7[d]

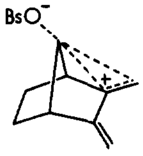
[a] Extrapolated rate constants. [b] Cited from ref 5.

[c] The rate for the brosylate was estimated, by use of the factor brosylate : tosylate = 2.9 : 1, from the acetolysis data for 8-Tos reported in ref 6. [d] Values for the corresponding tosylate.

It can be seen from Table I that the introduction of two exo double bonds into the anti-2 and anti-3 positions of 7 causes an increase in the rate of solvolyses by a factor of 10^4 (25°),[7] however, 1-OBs is less reactive than 8 by a factor of 10^7. The rate data and the major products formed suggest that the conjugated double bond system of 1-OBs exerts a substantial driving force during ionization of the C-OBs bond, although to quite a smaller degree than the single double bond in 8. It seems possible to explain the rate acceleration by assuming either simultaneous participation of the two double bonds leading to a symmetrical transition state such as 11, or participation of only one double bond leading to an unsymmetrical transition state such as 12 (one of the two enantiomorphic structures). From the standpoint of the simple HMO theory, transition state **11** will be ruled out because the highest occupied molecular orbital of a conjugated diene system has no plane of symmetry. Structures of all the products are accommodated by proposing the transition state **12** .

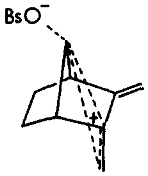


11



12

or



REFERENCES

1. As reviews, (a) P. D. Bartlett, *Nonclassical Ions*, W. A. Benjamin Publishers, New York, N.Y., 1965; (b) J. A. Berson, *Molecular Rearrangements*, Vol. 1, P. de Mays, Ed., Interscience, New York, N.Y., 1963, Chapter 3; (c) S. Winstein, *Quart. Rev., Chem. Soc.* **23**, 141 (1969).
2. (a) W. J. Bailey and W. B. Lawson, *J. Amer. Chem. Soc.* **77**, 1606 (1955); (b) M. A. P. Bowe, R. G. J. Miller, J. B. Rose, and D. G. M. Wood, *J. Chem. Soc.* 1541 (1960).
3. P. E. Eaton and R. A. Hudson, *J. Amer. Chem. Soc.* **87**, 2769 (1965).
4. M. Tichy, *Advan. Org. Chem.* **5**, 115 (1965).
5. H. Tanida, Y. Hata, S. Ikegami, and H. Ishitobi, *J. Amer. Chem. Soc.* **89**, 2928 (1967).
6. S. Winstein, M. Shatavsky, C. Norton, and R. B. Woodward, *J. Amer. Chem. Soc.* **77**, 4183 (1955).
7. The rate for **1**-OBs, if estimated by the Schleyer equation using the infrared carbonyl stretching frequency of **5**, attains rate assistance of 10^8. P. v. R. Schleyer, *J. Amer. Chem. Soc.* **86**, 1854, 1856 (1964).