Tetrahedron Letters No.40, pp. 3477-3479, 1969. Pergamon Press. Printed in Great Britain.

SOLVOLYSIS RATES OF 4,4-DIMETHYLCYCLOHEXYL TOSYLATE. EVIDENCE ON CONFORMATIONAL REACTIVITIES

J. Eric Nordlander, Judith M. Blank, and Satya P. Jindal

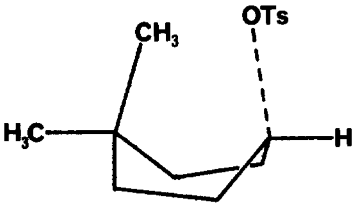
Department of Chemistry, Case Western Reserve University
Cleveland, Ohio 44106

(Received in USA 11 June 1969; received in UK for publication 29 July 1969)

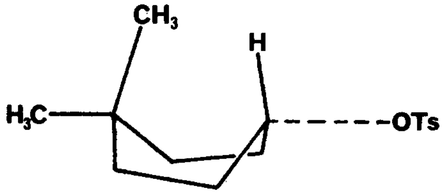
The conformational analysis of solvolytic displacement reactions of substituted cyclohexane derivatives has been a controversial topic. Winstein and Holness[1a] and Eliel and Ro[1b] first treated such systems in terms of rapidly interconverting axial- and equatorial-sulfonate chair-form ground states and the corresponding transition states; the position of ground-state equilibrium was evaluated by kinetic interpolation, using the cis- and trans-4-t-butyl substrates as conformationally pure models.[1a] This approach was criticized by Kwart and Takeshita,[2] who presented evidence taken to support a twist-boat transition state for a series of cis-4-substituted cyclohexyl tosylates, with the usual chair for the trans isomers. Shiner and Jewett, on the other hand, have inferred from deuterium isotope effects that trans-4-t-butylcyclohexyl brosylate solvolyzes through a non-chair transition state,[3a] while the cis isomer reacts by way of a skewed chair.[3b] A precise study of the products of these reactions by Whiting and coworkers[4] has provided support for the Shiner-Jewett conclusion. Recently Mateos, Perez, and Kwart[5] have concluded from kinetic data that cyclohexyl tosylate itself solvolyzes in acetic acid essentialy via a single transition state.

Saunders and Finley[6] have measured the β-deuterium isotope-effect pattern for the acetolysis of cyclohexyl tosylate, and judged the results to be most compatible with a twist-boat transition state for even this parent system.

We have carried out a test of the latter conclusion by measuring the comparative solvolysis rates of cyclohexyl and 4,4-dimethylcyclohexyl tosylate in acetic and trifluoroacetic acids. For reactions involving only chair conformers the gem-dimethyl group would be expected to provide only a minor rate enhancement, by virtue of the relayed 4-axial alkyl steric effect.[7] If in the unsubstituted system, however, a boat-like transition state is of significance, its geometry should be substantially distorted and its energy correspondingly increased by 4,4-dimethyl substitution, as in 1 (or, much less likely, 2).[8] The results are shown in Table I.



1



2

Table I. Solvolysis Rate Constants[a]

Compound	Solvent	Temperature, °C	10^4k_1	Relative k_1
4,4-Dimethylcyclohexyl OTs	CH_3CO_2H [b,c]	70.0	0.271	1.14
		85.0	1.41	
		100.0	6.53	
	CF_3CO_2H [d]	25.0	3.50	1.77
Cyclohexyl OTs	CH_3CO_2H [e]	70.0	0.237	1.0
	CF_3CO_2H [d]	25.0	1.98	1.0

[a] Good first-order behavior was observed in all cases. [b] Substrate 0.05 M in unbuffered glacial acetic acid containing 1 wt-% acetic anhydride; rates measured titrimetrically by the procedure of S. Winstein, C. Hanson, and E. Grunwald, J. Am. Chem. Soc., 70, 812 (1948). [c] $\Delta H^{\neq}$ = 26.3 kcal/mole, $\Delta S^{\neq}$ = -2.8 cal/deg-mole. [d] Substrate 0.05 M in trifluoroacetic acid containing 1 wt-% trifluoroacetic anhydride and 0.06-M sodium trifluoroacetate; rate determined spectrophotometrically as described in J. E. Nordlander and W. G. Deadman, ibid., 90, 1590 (1968). [e] H. C. Brown and G. Ham, ibid., 78, 2735 (1956).

The 4,4-dimethyl grouping causes no marked rate retardation, but instead a slight acceleration. The data are in accord with chair-form transition states for both substrates; no support is provided for a non-chair activated complex for cyclohexyl tosylate, as suggested earlier.[6] The close correspondence of the data between solvents as different as acetic and trifluoroacetic acids[9] would seem to secure this conclusion.

Whereas non-chair conformations may thus be discounted in the present reactions, considerable evidence has also accumulated to indicate[2,5,7e,10] that the Winstein-Holness quantitative chair-chair analysis of such systems[1a] is rather an oversimplification. In particular it appears unjustified to assume that the 4-t-butyl group provides conformational homogeneity *without causing appreciable ground- or transition-state distortions of the cyclohexane ring.*

Acknowledgment. Support of this work by National Science Foundation Grant GP-6074 is gratefully acknowledged.

References

(1) (a) S. Winstein and N. J. Holness, J. Am. Chem. Soc., 77, 5562 (1955); (b) E. L. Eliel and R. S. Ro, Chem. Ind. (London), 1956, 251.

(2) H. Kwart and T. Takeshita, J. Am. Chem. Soc., 86, 1161 (1964).

(3) (a) V. J. Shiner, Jr., and J. G. Jewett, ibid., 87, 1383 (1965); (b) V. J. Shiner, Jr., and J. G. Jewett, ibid., 87, 1382 (1965).

(4) N.C.G. Campbell, D. M. Muir, R. R. Hill, J. H. Parish, R. M. Southam, and M. C. Whiting, J. Chem. Soc., B, 1968, 355.

(5) J. L. Mateos, C. Perez, and H. Kwart, Chem. Comm., 1967, 125.

(6) W. H. Saunders, Jr., and K. T. Finley, J. Am. Chem. Soc., 87, 1384 (1965).

(7) (a) E. L. Eliel and C. A. Lukach, ibid., 79, 5986 (1957); (b) R. A. Benkeser and E. W. Bennet, ibid., 80, 5414 (1958); (c) J. C. Richer, L. A. Pilato, and E. L. Eliel, Chem. Ind. (London), 1961, 2007; (d) E. L. Eliel, N. L. Allinger, S. J. Angyal, and G. A. Morrison, "Conformational Analysis," Interscience Publishers, New York, 1965, p. 115; (e) E. L. Eliel and F. J. Biros, J. Am. Chem. Soc., 88, 3334 (1966); (f) C. W. Jefford, D. T. Hill, and J. Gunsher, ibid., 89, 6881 (1967); (g) F. G. Bordwell and R. G. Scamehorn, ibid., 90, 6748 (1968).

(8) In previous deductions, cited above, of twist-form transition states in the absence of polar substituents, the pseudo-axial or -equatorial orientation of the leaving group has not been specified. Presumably such a conformation would be adopted largely to allow more effective nucleophilic solvent participation; 1 would thus be greatly preferred over 2,

(9) (a) J. E. Nordlander and W. J. Kelly, ibid., 91, 996 (1969), and references therein; (b) A. Streitwieser, Jr., and G. A. Dafforn, Tetrahedron Letters, 1969, 1263.

(10) (a) E.A.S. Cavell, N. B. Chapman, and M. D. Johnson, J. Chem. Soc., 1960, 1413; (b) F. Shah-Malak and J.H.P. Utley, Chem. Comm., 1967, 69.