

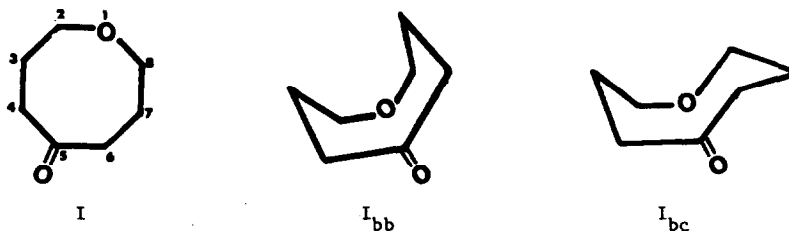
THE CONFORMATION OF 5-OXOCANONE  
EVIDENCE FROM 251 MHz  $^1\text{H}$  AND 63 MHz  $^{13}\text{C}$  NMR

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Some time ago, Leonard, Milligan, and Brown<sup>1</sup> tentatively assigned a boat-boat conformation ( $I_{bb}$ ) to 5-oxocanone (1-oxacyclooctan-5-one) (I), a compound with a potential transannular interaction of the ether oxygen with the carbonyl group. However, recent work has shown that simple cyclooctane derivatives,<sup>2</sup> including cyclooctanone<sup>3</sup> and oxacyclooctane<sup>4</sup> exist predominantly in boat-chair rather than boat-boat conformations.



We have now investigated the  $^1\text{H}$  and  $^{13}\text{C}$  nmr spectra of I at low temperatures and have obtained evidence which is incompatible with the boat-boat conformation, but which does fit nicely with the unsymmetrical boat-chair form ( $I_{bc}$ ).

The 251 MHz  $^1\text{H}$  spectrum of I at room temperature shows the presence of three chemical shifts. The lowest-field band, which can be assigned to the  $\text{CH}_2\text{O}$  protons, exhibits clear-cut changes at low temperatures as shown in Figure 1. At intermediate temperatures ( $\approx 96^\circ$ ), these protons give rise to two well-separated bands. At lower temperatures ( $< -104^\circ$ ) four chemical shifts are discernable. The 63 MHz  $^{13}\text{C}$  spectra of I at various temperatures are shown in Figure 2. Here, only a single process is observed and each of the  $^{13}\text{C}$  lines, with the exception of the carbonyl carbon band, splits at low temperatures into equal-intensity doublets.

The  $^1\text{H}$  and  $^{13}\text{C}$  spectra of I are inconsistent with the boat-boat conformation, which, because of its  $C_s$  symmetry, cannot exhibit more than two chemical shifts for the  $\text{CH}_2\text{O}$  protons or more than one shift for the  $\text{CH}_2\text{O}$  carbons. The results are consistent with a boat-chair, provided that the carbonyl and ether functions do not lie on the plane of symmetry of the boat-chair skeleton.

Chemical shift and kinetic parameters for the proton and carbon spectra are given in Table I. It is clear that the higher-temperature process observed in the proton spectrum has no effect on the carbon spectrum. Therefore this process, with a  $\Delta G^\ddagger$  of  $9.0 \pm 0.2$  kcal/mole, corresponds to a net exchange of two methylene protons on the same carbon atom and can be referred to as a ring inversion.

Table I. Nmr kinetic parameters for oxacyclooctan-5-one

Nucleus Observed	Chemical Shift Separation in Hz at ( $^\circ\text{C}$ )	Coalescence Temperature ( $T_c$ ) in $^\circ\text{C}$	$k$ ( $\text{sec}^{-1}$ ) at $T_c$	$\Delta G^\ddagger$ (kcal/mole) at $T_c$
$^1\text{H}$	$68^a$ ( $-96^\circ$ )	$-88 \pm 3$	150	$9.0 \pm 0.2$
$^1\text{H}$	$80^a$ ( $-126^\circ$ )	$-104 \pm 3$	180	$7.9 \pm 0.2$
$^{13}\text{C}$	$477^b$ ( $-125^\circ$ )	$-97 \pm 3$	1060	$7.7 \pm 0.2$

} av. 7.8

<sup>a</sup> for protons on C-2 and C-8; <sup>b</sup> for C-3 and C-7 carbons.

The lower-temperature process, with a  $\Delta G^\ddagger$  of  $7.8 \pm 0.2$  kcal/mole, when taking place rapidly on the nmr time scale, introduces a time-average element of symmetry, which must be either a plane of symmetry or a  $C_2$  axis passing in either case only through the C=O and ether functions. If the mechanism responsible for this process is a series of boat-chair  $\rightarrow$  twist-boat-chair  $\rightarrow$  boat-chair cycles, as has been postulated in the analogous cyclooctanone situation,<sup>3</sup> the element of symmetry introduced is the  $C_s$  plane, and the overall process can be described most simply as a conformational racemization of a chiral conformation.

The  $I_{bc}$  conformation fits not only the nmr evidence presented above, but also the dipole moment  $(4.09\text{D})^1$  of I. Unsymmetrical boat-chairs other than  $I_{bc}$  are unfavorable because they should have much more non-bonded repulsion than does  $I_{bc}$ . Finally, an unsymmetrical crown-family form is quite unlikely for I since it would be expected to show only a single process down to at least  $-160^\circ$ .<sup>5</sup>

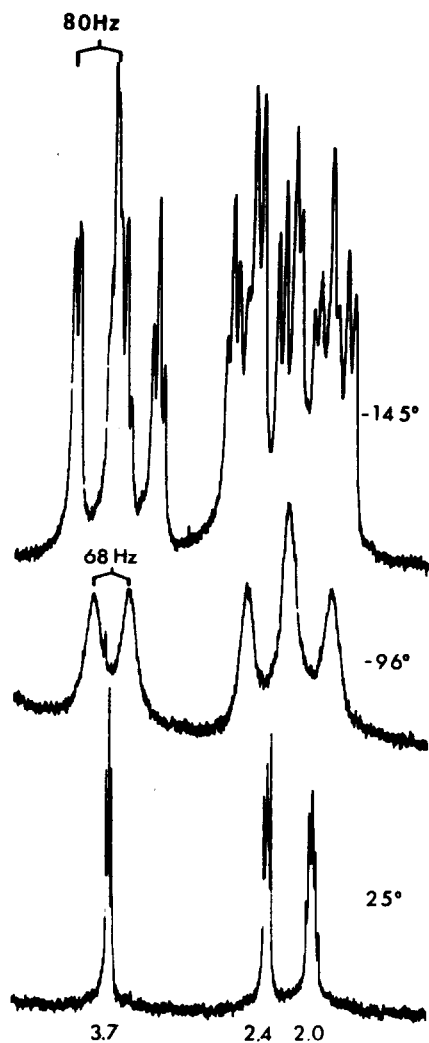


Figure 1. 251 MHz  $^1\text{H}$  nmr spectra of 5-oxocanone in a mixture of  $\text{CHCl}_2\text{F}$  and  $\text{CHClF}_2$ . The scale is ppm downfield from internal TMS.

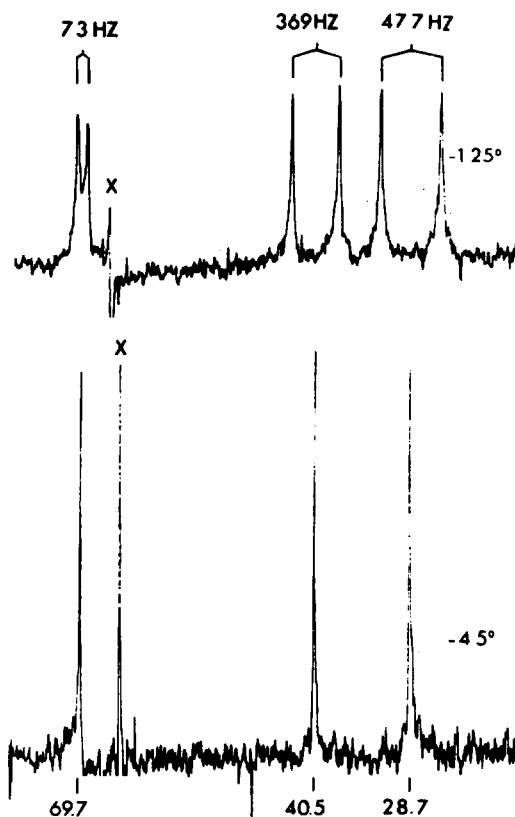


Figure 2. 63.1 MHz Fourier-transform  $^{13}\text{C}$  nmr spectra of 5-oxocanone in  $\text{CHCl}_2\text{F}$ . Protons are noise decoupled and 250 free induction decays were accumulated. The scale is ppm downfield from internal TMS. The carbonyl  $^{13}\text{C}$  is at 218 ppm and is not shown. The line marked by an X is a spurious beat frequency.

The conformational barriers occurring in I are each about 1.5 kcal/mole higher than the corresponding barriers in cyclooctanone.<sup>3</sup> This is understandable since the transannular interaction between the carbonyl group and the ether oxygen in I<sub>bc</sub> is very likely to be greatly reduced in the transition states for the conformational processes occurring in I. Even higher conformational barriers can be predicted for N-methylazacyclooctan-5-one, since the transannular interaction in this compound is known from infrared measurements to be much larger than in I.<sup>6</sup>

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#### References

1. N. J. Leonard, J. W. Milligan and T. L. Brown, *J. Amer. Chem. Soc.*, 82, 4075 (1960).
2. F. A. L. Anet in "Conformational Analysis", by G. Chiurdoglu, Ed., Academic Press, New York, N. Y., 1971, p. 15; J. E. Anderson, E. S. Glaser, D. L. Griffith, R. Knorr and J. D. Roberts, *J. Amer. Chem. Soc.*, 91, 1386 (1969), P. Groth, *Acta. Chem. Scand.* 19, 1497 (1965), J. V. Egmond and C. Romer, *Tetrahedron*, 25, 2693 (1969), H. B. Burgi and J. D. Dunitz, *Helv. Chim. Acta.*, 51, 1514 (1968).
3. F. A. L. Anet and M. St. Jacques, *J. Amer. Chem. Soc.*, 88, 2585, 2586 (1966); F. A. L. Anet, M. St. Jacques and P. M. Henrichs, *Intra-Sci. Chem. Rep.*, 4, 251 (1970).
4. F. A. L. Anet and P. J. Degen, *J. Amer. Chem. Soc.*, 95, 1390 (1972).
5. J. B. Hendrickson, *J. Amer. Chem. Soc.*, 89, 7036, 7043, 7047 (1967).
6. N. J. Leonard, R. C. Fox, M. Oki and S. J. Chiavarilli, *J. Amer. Chem. Soc.*, 76, 630 (1954).