

Direct Observation of Boat–Chair \rightleftharpoons Chair–Boat Equilibrium in the 3,7-Diazabicyclo[3.3.1]nonane Ring

By YOSHITO TAKEUCHI,*

(Department of Chemistry, College of General Education, The University of Tokyo, Komaba, Meguro-ku, Tokyo, Japan 153)

PAL SCHEIBER*

(Department of Chemistry, The Veterinary University, Budapest, Hungary)

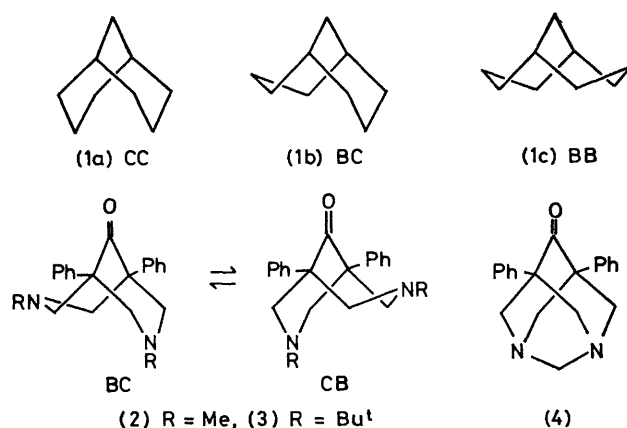
and KANAKO TAKADA

(Kawamura Research Institute, Kamikizaki, Urawa-shi, Saitama, Japan 338)

Summary Variable-temperature ^{13}C n.m.r. spectra of 3,7-dialkyl-1,5-diazabicyclo[3.3.1]nonan-9-ones unambiguously establish a boat–chair \rightleftharpoons chair–boat equilibrium rather than the fixed double-chair conformation which had previously been proposed.

THE stereochemistry of derivatives of bicyclo[3.3.1]nonane (**1**) is of great interest because of its connection with the dynamic stereochemistry of cyclohexane.¹ Of the three possible conformations [double chair (**1a**, CC), boat-chair (**1b**, BC), and double boat (**1c**, BB)] it seems established that the first is, although somewhat flattened, the most stable, by analogy with cyclohexane. This analogy is supported by ample theoretical² and experimental³ evidence, and is also claimed to be applicable to heterocyclic compounds with nitrogen and oxygen atoms in the 3- or 3- and 7-positions of the ring.⁴

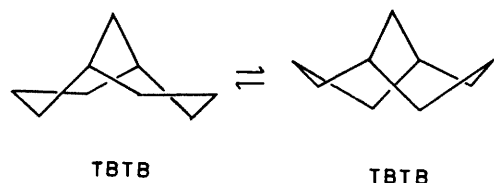
Scheiber and Nádor⁵ have proposed, however, a BC conformation for 3,7-dialkyl-1,5-diphenyl-3,7-diazabicyclo[3.3.1]nonan-9-one [(**2**), R = Me; (**3**), R = Bu^t], based chiefly on the comparison of the dipole moment of (**2**) (3.34 D) with that of analogous compounds including diaza-adamantane (**4**) (1.94 D) in which the two piperidone



rings are necessarily fixed in a chair conformation. They also proposed a rapid BC \rightleftharpoons CB equilibrium since the ambient-temperature ^1H n.m.r. spectra of (**2**) and (**3**) show only one AB quartet, rather than two, for the methylene protons.

We now describe the direct observation of this $BC \rightleftharpoons CB$ equilibrium in (2) and (3) from a variable-temperature ^{13}C n.m.r. (^{13}C dynamic n.m.r.) study.† At ambient temperatures (2) exhibits only three peaks [δ_{C} 45.5 (N-CH₃), 54.5 (C-1,5), and 67.9 (CH₂)] in the aliphatic region. Off-resonance decoupling unequivocally established this assignment. As the temperature was lowered, the CH₂ singlet gradually broadened, coalesced at -63°C , and finally split into two peaks of equal intensity. At the slow exchange limit, the maximum chemical shift difference was 6.0 p.p.m. This dynamic n.m.r. behaviour could be simulated using a simple A to B exchange model; ΔG^\ddagger was 9.7 kcal/mol at -63°C for the exchange process.

This line splitting observation, together with the fact that the C-1,5 signal remains as a sharp singlet throughout the temperature range investigated, is consistent with the freezing out of a structure of two-fold symmetry (C_s or C_2), at -63°C , implying a $BC \rightleftharpoons CB$ equilibrium. A double



twist-boat (TBTB) \rightleftharpoons double twist-boat equilibrium is also possible but the averaging motion is pseudorotational and is expected to have a very low energy barrier. A chemical shift difference of 6 p.p.m. for C-2 and C-4 (and hence C-6 and C-8) is also very unlikely.

Another alternative, which is even less likely, is a slow double nitrogen inversion with a fixed CC conformation. The barrier for *N*-methyl inversion for piperidine is thought to be 8.7 kcal/mol (equation to transition state).⁶ Furthermore, from symmetry requirements equatorial and axial conformers should be equally populated, which is highly unlikely. Indeed, the methylene carbons of (3) show no spectral changes below temperatures at which nitrogen inversion is prohibited.

A $BC \rightleftharpoons CB$ equilibrium was proposed to explain the ^{13}C dynamic n.m.r. spectrum of the bicyclo[3.3.1]nonan-9-yl cation.⁷ The CH₂ signal of this compound merely continues to broaden as the temperature decreases, and fails to indicate 'freezing out' at temperatures as low as -150°C . Hence, to the best of our knowledge, this communication reports the first, direct observation of a $BC \rightleftharpoons CB$ equilibrium for the bicyclo[3.3.1]nonane system.

Y.T. thanks the Ministry of Education for a grant-in-aid.

(Received, 31st December 1979; Com. 1346.)

† ^{13}C n.m.r. spectra were determined with Varian FT-80A and JEOL FX-100 spectrometers for solutions of ca. 50 mg of sample in 1 ml of $\text{CD}_2\text{Cl}_2\text{-CS}_2$ (1:1 v/v).

¹ N. S. Zefirov, *Usp. Khim.*, 1975, **44**, 413; *Russ. Chem. Rev. (Engl. Transl.)*, 1976, **44**, 196.

² G. J. Gleicher and P. von R. Schleyer, *J. Am. Chem. Soc.*, 1967, **89**, 582; N. L. Allinger, M. T. Tribble, M. A. Miller, and D. H. Wert, *ibid.*, 1971, **93**, 1637.

³ W. A. C. Brown, M. Martin, and G. A. Sim, *J. Chem. Soc.*, 1965, 1844; E. Osina, V. S. Mastryukov, L. V. Vilkov, and N. A. Belikova, *J. Chem. Soc., Chem. Commun.*, 1976, 12.

⁴ J. E. Douglass and T. B. Ratliff, *J. Org. Chem.*, 1968, **38**, 355; M. Dobler and J. D. Dunitz, *Helv. Chim. Acta*, 1964, **47**, 695; M. R. Chakrarty, R. L. Ellis, and J. L. Roberts, *J. Org. Chem.*, 1970, **35**, 541.

⁵ P. Scheiber and K. Nádor, *Acta Chim. Acad. Sci. Hung.*, 1975, **84**, 193.

⁶ A. R. Katritzky, R. C. Patel, and F. G. Riddell, *J. Chem. Soc., Chem. Commun.*, 1979, 674.

⁷ R. P. Kirchen and T. S. Sørensen, *J. Am. Chem. Soc.*, 1978, **100**, 1487.