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ANALYSIS OF THE CONFORMATIONAL COMPOSITION OF 2-ALKYL-4-PHENYL-1,3,2-OXAZABORINANES

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The empirical MM2 and semiempirical AM1 methods were used to calculate the energy of model 2-methyl-4-phenyl-1,3,2-oxazaborinane with full optimization of the molecular geometry. Comparison of the experimental coupling constants for the 2-isobutyl analog and calculated coupling constants as well as the data for the relative energy of the individual conformers indicated that these compounds form a multicomponent equilibrium system containing sofa and a family of half-chair forms.

Keywords: 2-alkyl-4-phenyl-1,3,2-oxazaborinanes, conformational composition, molecular mechanics methods.

The effect of three different heteroatoms on the conformational properties of alkyl-substituted cyclic borates of 1,3-aminoalcohols is seen in the predominance of half-chair forms, which are comparable in stability to the canonical sofa conformation [1]. On the other hand, introduction of an aromatic substituent in 1,3-heterocycles leads to a change in the magnetic anisotropy properties of the molecule and has a significant effect on the conformational equilibrium [2-4]. In the present work, we studied the conformational composition of 2-isobutyl-4-phenyl-1,3,2-oxazaborinane (**1**) and model 2-methyl analog (**2**) by the MM2 molecular mechanics method [5] and the LCAO MO SCF method with AM1 parameters [6, 7] in conjunction with the ^{1}H NMR spectral data.

Borinane **1** was prepared by the reaction of the diisobutyl ester of isobutylboric acid with 3-amino-3-phenyl-1-propanol obtained, in turn, by the reaction of 4-phenyl-1,3-dioxane with acetonitrile and subsequent hydrolysis of 4-phenyl-5,6-dihydro-1,3-oxazine [8, 9].

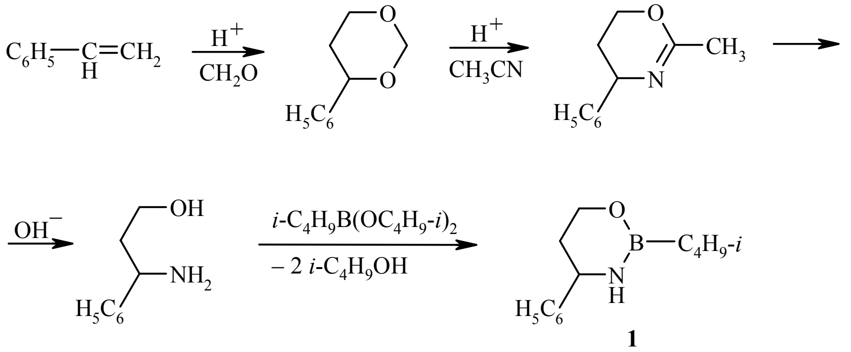

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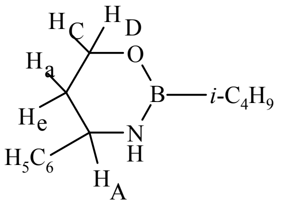
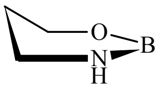
TABLE 1. ^{1}H NMR Spectral Parameters of Ester **1**



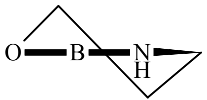
Chemical shifts, ppm				Coupling constants, Hz	
H_A	H_a	H_c	H_C/H_D	$^3J_{Aa}$	$^3J_{Ae}$
4.35	1.71	2.09	3.91	7.8	4.8

The ^{1}H NMR spectral parameters of ester **1** given in Table 1 indicate a slight lack of equivalence of H_C and H_D at $C_{(6)}$ in the ring, which gives rise to a poorly resolved multiplet.

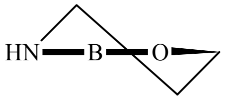
This finding along with the coupling constants $^3J_{Aa}$ and $^3J_{Ae}$ as well as the spectrum calculated using the PANIC program have already suggested the predominance of the 3,6-twist conformation for this molecule [10]. The energy calculation for model ester **2** with complete geometry optimization undertaken to check this conclusion revealed a series of minima on the potential energy surface corresponding to the sofa conformation (S), a family of half-chair conformations (HC1-HC4), and the 1,4-, 3,6-, and 2,5-twist conformations (1,4-, 3,6-, and 2,5-T) with equatorial (e) or axial (a) orientation of the phenyl substituent. The half-chair conformers differ only in the extent of deformation of the $C_{(4)}$NBO and $C_{(6)}$OBN fragments. All the forms except S were obtained on the condition of fixing the torsion angles indicated above. Otherwise, they would isomerize to the sofa.



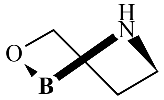
S



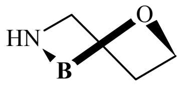
HC1, HC3



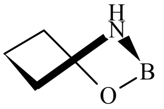
HC2, HC3



1,4-T



3,6-T



2,5-T

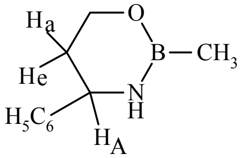
The data in Table 2 indicate that the stability of the conformers of ester **2** decreases in the series: S ≥ HC > 1,4-T > 3,6-T > 2,5-T. The equatorial forms are 1.7-1.0 kcal/mole more favorable than the axial conformers. It is readily seen that the major minimum is rather compressed and contains a series of conformers with energy differences up to 1.1 kcal/mole (S_a and most of the half-chair forms both with equatorial and axial phenyl group) in addition to the S_e form. On the other hand, the low probability for the existence of the rather unstable 3,6-T conformer in considerable amounts permits us to exclude it from consideration.

Coupling constants $^3J_{Aa}$ and $^3J_{Ae}$ of the S and HC conformers were calculated to evaluate the actual existence of these forms with similar energy using the torsion angles φ between the corresponding protons (optimal geometry data) using the equation of Durette and Horton [11] and electronegativities of the substituents [12]. Comparison with the experimental coupling constants (Table 3) indicated that the actual state of esters **1** and **2** corresponds to an equilibrium mixture of all nine forms. This conclusion is indicated by the similar values of $\Sigma|\Delta J|$. The major reason for the existence of such a broad compressed minimum is the reduction in the

TABLE 2. Relative Energies of Conformers of Ester **2** (kcal/mole)

Conformer	MM2	AM1	Conformer	MM2	AM1
S_e	0.0	0.0	HC 3_a	1.0	1.0
S_a	0.7	1.0	HC 4_e	0.1	0.4
HC 1_e	0.3	0.2	HC 4_a	0.8	1.3
HC 1_a	1.0	1.1	1,4-T_e	1.8	1.8
HC 2_e	0.4	0.9	1,4-T_a	2.8	2.7
HC 2_a	1.2	1.7	3,6-T_e	2.9	3.1
HC 3_e	0.2	0.0	2,5-T	6.6	4.0

TABLE 3. Torsion Angles Between Protons (deg) and Coupling Constants (Hz) for the Most Stable Conformers of Ester **2**



Confor-mer*	MM2					AM1				
	φ_{Aa}	φ_{Ae}	$^3J_{Aa}$	$^3J_{Ae}$	$\Sigma\lvert ?J\rvert^{*2}$	φ_{Aa}	φ_{Ae}	$^3J_{Aa}$	$^3J_{Ae}$	$\Sigma\lvert ?J\rvert^{*2}$
S_e	178.0	60.9	11.4	3.5	4.7	165.1	47.0	10.8	5.3	3.7
S_a	50.3	66.0	4.9	2.9	4.6	37.3	80.4	6.8	1.9	3.7
HC 1_e	174.9	57.8	11.4	3.9	4.3	163.8	45.7	10.7	5.5	3.8
HC 1_a	47.5	68.7	5.3	2.6	4.5	35.8	81.9	7.0	1.8	3.6
HC 2_e	178.5	64.4	11.4	3.1	4.6	169.4	51.5	11.1	4.7	3.4
HC 3_e	173.1	56.1	11.3	4.1	4.0	163.6	45.5	10.7	5.5	3.8
HC 3_a	46.8	69.5	5.4	2.6	4.4	35.9	81.7	6.9	1.8	3.7
HC 4_e	179.6	63.3	11.4	3.2	5.0	169.1	51.2	11.1	4.7	3.4
HC 4_a	52.1	64.2	4.6	3.1	4.7	40.6	76.9	6.3	2.0	4.1

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* Conformer HC 2_a not considered due to its relative instability.

$*^2$ $\Sigma|\Delta J| = |{}^3J_{Aa}$ exp. – $^3J_{Aa}$ calc.$|$ + $|{}^3J_{Ae}$ exp. – $^3J_{Ae}$ calc.$|$.

number of nonbonded interactions in the six-membered cyclic borate of 1,3-aminoalcohols due to the planar configuration of the boron and nitrogen atoms, characteristic for systems whose geometry permits *p*–π interaction along the B–N bond [13].

Thus, these compounds, similar to the corresponding alkyl-substituted analogs [1], are conformationally flexible systems, permitting the existence of a considerable number of geometrically nonequivalent forms near the minimum.

EXPERIMENTAL

The ^{1}H NMR spectra were taken on a Bruker AM-250 spectrometer at 250 MHz for 10% solutions of **1** in $CDCl_3$ with TMS as the internal standard. A sample of 3-amino-3-phenyl-1-propanol was obtained according to our previous procedures [8, 9]. Starting 4-phenyl-1,3-dioxane was obtained according to Emerson [14]. The diisobutyl ester of isobutylboric acid was obtained according to our earlier procedure [15], while ester **1** was obtained according to our procedure [16] in 60% yield, bp 140-144°C (4 mm Hg), n_D^{20} 1.5162.

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