

## Spectroscopic Properties of *endo*-Substituted D-(+)-Camphor Derivatives

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**Summary** C.d. and u.v. spectra of several *endo*-substituted aminocamphor derivatives have been measured: the results follow certain trends which are rationalised by spectroscopic rules previously postulated.

A NUMBER of *endo*-substituted camphors were synthesized in connection with work<sup>1</sup> on conformationally rigid derivatives of acetylcholine analogues. Some of these compounds are suitable models for verification of the recently suggested spectroscopic rules for carbonyl compounds.<sup>2</sup>

The spectroscopic data for the compounds in the two solvents methanol and n-hexane parallel one another (Table); therefore only the comparison of the results for the free bases and their hydrochlorides in methanol is discussed.

U.v. spectra: The introduction of an  $\alpha$ -amino-group (**1**; R = NHMe and **1**; R = NHEt) into bornanone (**1**; R = H) causes a red shift (Rule i<sup>2</sup>) due to coupling of the  $\pi$ ,  $\pi^*$  with  $\sigma$ ,  $\sigma^*$  energy levels which is enhanced when the lone pair of the nitrogen can adopt a W arrangement with respect to one of the lobes of the  $\pi$  orbital of the carbonyl group (Rule ii<sup>2</sup>) (*e.g.* in **1**; R = NH<sub>2</sub>).

Protonation of the nitrogen in these examples removes the lone pair thus reducing the red shift of the basic group. The remainder of the red shift is due to C $_{\alpha}$ -N<sup>+</sup>.

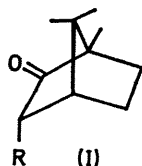
The same value of  $\lambda_{\max}$  for the *NN*-dimethylaminobornanone (**1**; R = NMe<sub>2</sub>) and its hydrochloride, which is also near to the  $\lambda_{\max}$  value of its corresponding trimethylammonium compound (**1**; R = N<sup>+</sup>Me<sub>3</sub>Br<sup>-</sup>) indicates that the lone

## C.d. and u.v. spectra of 3-endo-substituted D-(+)-camphor derivatives

Compound (1) R	Spectral data in methanol								Spectral data in n-hexane			
	Bases				Hydrochlorides				Bases			
	C.d.		U.v.		C.d.		U.v.		C.d.		U.v.	
$\lambda_{\max}(\text{nm})$	$\Delta\epsilon$	$\lambda_{\max}(\text{nm})$	$\epsilon$	$\lambda_{\max}(\text{nm})$	$\Delta\epsilon$	$\lambda_{\max}(\text{nm})$	$\epsilon$	$\lambda_{\max}(\text{nm})$	$\Delta\epsilon$	$\lambda_{\max}(\text{nm})$	$\epsilon$	
H	297	+1.52	290	33				302	+1.69	292	24	
Et	300	+1.81	292	37				310	+2.01	295	31	
NH <sub>2</sub> <sup>a</sup>	310	+2.31	308	54.5	316sh	+0.61	298.5	32	314.5	+1.90	304.5	39
NHMe	312	+1.53	300	44.5	309	+0.71	298	35.5	313	+0.84	293	36
					309	+0.89			305	+0.80	293	36
NHEt <sup>a</sup>	313	+1.24	300	54	310	+0.79	298	37	312	+0.78	300	37
					312	+0.79			312	+0.78	300	37
NMe <sub>2</sub> <sup>a</sup>	323	+0.41	304	29	323	+0.48	304	35	324	+0.71	300	25
	313	+0.31			312	+0.57			312	+0.66		
CH <sub>2</sub> NHMe	300	+1.81	296	50	301	+1.30	293	40	301	+0.37	296	60
					301	+1.30			303	+1.82	296	60
CH <sub>2</sub> NMe <sub>2</sub>	300	+1.86	294	52	299	+1.31	292	43.5	312	+1.57	296	49
					299	+1.31			303	+1.80	296	49
CH <sub>2</sub> CH <sub>2</sub> NMe <sub>2</sub>	300	+1.84	295	45	301	+1.35	293	41	312	+1.80	294	38
					301	+1.35			303	+2.16	294	38
N <sup>+</sup> Me <sub>3</sub> Br <sup>-a</sup>					312	+1.04	300	37				
CH <sub>2</sub> N <sup>+</sup> Me <sub>2</sub> Br <sup>-</sup>					299	+1.63	292.5	45				
CH <sub>2</sub> CH <sub>2</sub> N <sup>+</sup> Me <sub>2</sub> Br <sup>-</sup>					300	+1.54	295.5	39				

<sup>a</sup> Analytical data published.<sup>1</sup> Other compounds in Table had correct analytical and spectral data.

pair is no longer involved, since the orientation is unfavourable for coupling because of the non-bonded interactions between the methyl group and the C-5 *endo*-position.<sup>§</sup> The extinction coefficients of all the above compounds follow Rule iii.<sup>§</sup>



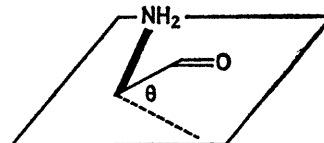
The spectral data of  $\beta$ - and  $\gamma$ -aminoketones (**1**; R = CH<sub>2</sub>NHMe, CH<sub>2</sub>NMe, and CH<sub>2</sub>CH<sub>2</sub>NMe<sub>2</sub>, respectively) indicate that the C-N bond and the lone pair have now hardly any effect (*c.f.* **1**; R = Et) on the position of  $\lambda_{\max}$  because of conformationally incorrect orientation for coupling.

C.d. spectra: The  $\Delta\epsilon$  value of  $\alpha$ -aminobornanone (**1**; R = NH<sub>2</sub>) exhibits "octant" behaviour as predicted by Rules ii, iii, and iv<sup>§</sup> (see above).

The introduction of *N*-methyl, *N*-ethyl, and *N*-dimethyl substituents (**1**; R = NHMe, NHEt, and NMe<sub>2</sub>, respectively) into bornanone (**1**; R = H) produces increasing conformational restraint which results in incorrect orientation of the lone pair for coupling and thus leads to an increasing "antioctant" trend. This may also be in part due to

decreasing availability of the lone pair for back-donation<sup>¶</sup> because of Bohlmann coupling.<sup>§</sup>

The  $\Delta\epsilon$  values of  $\beta$ - and  $\gamma$ -aminoketones (**1**; R = CH<sub>2</sub>NHMe, CH<sub>2</sub>NMe, and CH<sub>2</sub>CH<sub>2</sub>NMe<sub>2</sub>, respectively) are similar to that of  $\alpha$ -ethylbornanone (**1**; R = Et) indicating that the "antioctant" contribution of the C-N bond is counterbalanced by the "octant" contribution of the nitrogen lone pair in the various possible conformations of the side chain. The protonation of these compounds removes the "octant" contribution of the lone pair, thus resulting in "antioctant" behaviour.



The enhancement of the value of  $\Delta\epsilon$  of bornanone (**1**; R = H) by the introduction of the  $\alpha$ -amino-group (**1**; R = NH<sub>2</sub>) [ $\Delta(\Delta\epsilon) + 0.8$ ] is not so great as that produced by the introduction of the 5 $\alpha$ -amino-group into 3 $\beta$ -acetoxycholestan-6-one<sup>4</sup> [ $\Delta(\Delta\epsilon) - 3.2$ ]; this is probably due to the dihedral angle between the carbonyl group and C <sub>$\alpha$</sub> -N bond being *ca.* 60° in the former case and 116° in the latter (Figure 1).

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<sup>§</sup> The introduction of the *N*-methyl group into *N*-methylaminobornanone increases the red shift, possibly due to an increase in the energy of the  $\sigma$  orbital of the N-C <sub>$\alpha$</sub>  bond (lowering of  $\sigma^*$ ) with attendant larger coupling of the  $\pi$  and  $\pi^*$  levels.

<sup>¶</sup> Unpublished work (G. P. Powell, M. T. Hughes, and J. Hudec) shows that the lone pair interacts with the  $\pi^*$  orbital by back-donation. The reverse applies to the  $\sigma^*$  orbital of the C-N bond which withdraws electrons from the  $\pi$  orbital.

<sup>1</sup> A. H. Beckett, N. T. Lan, and G. R. McDonough, *Tetrahedron*, 1969, 25, 5689 and 5693.

<sup>2</sup> J. Hudec, *Chem. Comm.*, 1970, 829.

<sup>3</sup> F. Bohlmann, *Chem. Ber.*, 1958, 91, 2157; T. Masamune and M. Takasugi, *Chem. Comm.*, 1967, 625; T. Masamune, *ibid.*, 1968, 244; H. P. Hamlow, S. Okuda, and N. Nagakawa, *Tetrahedron Letters*, 1964, 2553.

<sup>4</sup> G. Snatzke and A. Veithen, *Annalen*, 1967, 703, 159.