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HIGH ROTATIONAL BARRIERS ABOUT C-N BONDS IN ARYL SUBSTITUTED HETEROCYCLIC COMPOUNDS LACKING BULKY ORTHO SUBSTITUENTS

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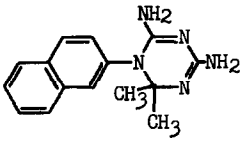
We have previously reported high barriers to rotation about aryl C-N bonds in aryl-substituted heterocyclic compounds.[1] In these compounds the energy of the transition state for rotation is high because of steric interference between a bulky ortho substituent on the aryl group and the heterocyclic moiety. We now report some examples of compounds in which there are substantial barriers to rotation in the absence of bulky ortho substituents and in which the asymmetric shieldings of the aryl groups are sufficient to cause chemical shift differences[2] between diastereotopic groups and between diastereomeric rotational isomers.

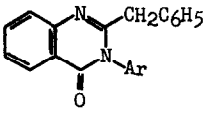
At room temperature, the diastereotopic methyl groups of 1-(β-naphthyl)-1,2-dihydro-2,2-dimethyl-4,6-diamino-s-triazine, (I), give rise to two lines, and the diastereotopic benzylic methylene protons of the 2-benzyl-3-aryl-4(3H)-quinazolinones, (IIa), (IIb), and (IIc), give rise to AB quartets, indicating slow rotation of the aryl group on the n.m.r. time scale. When the samples are heated the spectra arising from these protons collapse to a singlet in each case. Similarly, the 5-methine protons of the two diastereomeric rotational isomers of 3-(β-naphthyl)-5-methyl-2-thiohydantoin, (III), give rise to two overlapping quartets at room temperature, and a single, time averaged quartet at higher temperatures. The chemical shift differences, measured under conditions of slow rotation, are reported in the Table.

Rate constants were obtained for the coalescence point region by matching computer simulated spectra to the experimental spectra, making allowance for the natural linewidths. The small chemical shift differences precluded measurement of rate constants over an extended temperature range, so free energies of activation are reported in the Table for the coalescence point. Collapse of the methyl doublet of (I) was accompanied by some decomposition.

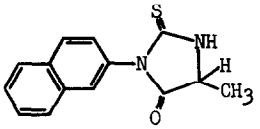
N.m.r. Data, Coalescence Temperatures, and Free Energies of Activation



(I)



(IIa) Ar = β-naphthyl
(IIb) Ar = 3-bromophenyl
(IIc) Ar = 3-acetylphenyl



(III)

	Solvent	Chemical shift difference[a]	J_{AB} (Hz)	Coalescence temperature[b]	$\Delta G^{\ddagger}$[c]
(I)	Perfluorobutyric acid	0.032[d]		141	23.1
(IIa)	Nitrobenzene	0.132	15.1	116	19.8
(IIb)	Nitrobenzene	0.088	15.1	94	18.9
(IIc)	Nitrobenzene	0.105	15.0	102	19.2
(III)	DMSO-d_6	0.011		97.5	21.7

(a) P.p.m. 100 MHz spectra. (b) Degrees C. (c) Free energy of activation (kcal/mole) at coalescence temperature. Errors are estimated to be less than ±0.3 kcal/mole. (d) Measured at 109°C.

It is noteworthy that the barriers to internal rotation in these compounds are quite high even though the small size of the hydrogen atoms in the ortho positions renders them poor blocking substituents. However, the steric requirements of one of the ortho hydrogen atoms may be increased by buttressing with the adjacent substituent. Compensation for the small effective size of the aryl groups is provided by the bulk and geometry of the heterocyclic groups, so that steric interaction between the two moieties in the transition state is severe.

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References: 1. W.E. Bentz, L.D. Colebrook, J.R. Fehlner, and A. Rosowsky, Chem. Commun., 974 (1970).

2. Since the chemical shift differences resulting from anisotropic shielding by the aryl groups may be small and solvent dependent, the choice of a solvent is important. For example, the room temperature spectrum of IIb in bromoform shows a singlet rather than an AB quartet in the methylene region at δ3.85.