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DETECTION OF THERMAL ISOMERIZATION OF HYDRAZONES BY NMR SPECTROSCOPY

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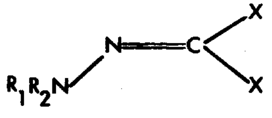
We would like to report our results concerning the detection, by variable temperature nmr spectroscopy, and evaluation of the rates of thermal (non-catalyzed) isomerization of hydrazones[1]. The nmr spectra at room temperature of all compounds in Table *I* exhibit two well resolved resonance lines for the CH_3 protons of the X groups. A gradual broadening and an eventual coalescence of these lines into a singlet was observed upon raising the temperature. The reversibility of these spectral changes was demonstrated. Such a behavior indicates the occurrence of a kinetic process which results in the exchange of the two diastereotopic X groups. This process can be identified only with the degenerate syn $\rightleftharpoons$ anti isomerization of hydrazones. The isomerization rate and ΔG^* at Tc (coalescence temperature) were evaluated by known procedures[2]. With most of the compounds of Table *I*, $\Delta\nu$ (X), when there is no exchange, is temperature dependent. Therefore, the rate at Tc was evaluated employing $\Delta\nu$ values obtained at the highest temperature before exchange occurs[3].

The salient conclusion emerging from the data in Table *I* is that the activation energy for the thermal syn/anti isomerization process in the hydrazones is practically insensitive to structural factors. This insensitivity may be contrasted with our recent results in substituted enamines[4]. From the results of Table *I* it can very well be seen that ΔG^* values respond sluggishly to extensive modifications in the electronic properties of the groups directly bound to the C=N bond. Of particular interest are the comparisons of compound (2) and (5), and (3) and (6). The substitution of the electron withdrawing carbomethoxy groups by electron releasing methyl groups did not affect the activation energy to a significant extent; neither did the exchange of an alkyl by one phenyl group on the tricoordinate nitrogen atom, (compare 1 and 3, and 5 and 6). The two X signals in the nmr spectra of the N,N-diphenyl hydrazones (4) and (7)(Table *I*) persist up to 200 and 170° respectively. Accordingly, a lower limit of ΔG^* was estimated.

To our knowledge, no systematic kinetic data for the syn/anti isomerization of N,N-disubstituted hydrazones are available in the literature[5]. In the light of our experimental results, it must be concluded that hydrazones isomerize by an in plane vibrational mechanism rather than by a rotational process about the C=N bond. The latter type of isomerization is necessarily associated with a charge separation in the transition state and is, therefore, expected to be pronouncedly affected by structural factors. The vibrational mechanism, on the other hand, is associated with re-hybridization of the sp^2 nitrogen atom in proceeding from the ground to the linear transition state. The situation is analogous to that in imines[6].

Cooling solutions of 1 and 2 resulted in the separation of the R_2N singlet, in each compound, to a broad doublet. This phenomenon has already been encountered by Mannschreck et al in dimethyl hydrazones[5]. Karabatsos et al have pointed out that in dialkyl hydrazones of ketones, the lone pair of the tricoordinate nitrogen atom is twisted out of conjugation with the C=N π system[7]. Granting such a chiral ground state conformation of 2, the benzyl protons in each group are diastereotopic. The failure to observe AB quartets for the benzyl protons of 2 at −100° implies that the combination of 1) inversion of the tricoordinate nitrogen atom and 2), its libration through the double bond plane (by two-fold the angle of twist) is fast on nmr time scale. Rotation about the N-N bond which leads to the conformation where the lone pair of the tricoordinate nitrogen atom is orthogonal to the C=N π system (max energy), must be the process responsible for the experimentally observed exchange of the two nitrogen substituents in 1 and 2.

Table *I*
NMR and Activation Data[a]



Compound	R_1	R_2	X	$\Delta\nu$ (X)[b] (CPS at T)	Tc (°C)	ΔG^* (Kcal/mole)
1	CH_3	CH_3	CO_2CH_3	6.3(35°)	156	23.2
2	ØCH_2	ØCH_2	CO_2CH_3	37.2(35°) 31.6(93°)	145.5	21.2
3[c]	CH_3	Ø	CO_2CH_3	4.0(60°) 5.0(100°)	157	23.4
4	Ø	Ø	CO_2CH_3	72(110°)	>200	>23.3[d]
5	ØCH_2	ØCH_2	CH_3	17(40°) 16(100°)	143	21.6
6	CH_3	Ø	CH_3	18(35°)	134	21.1
7	Ø	Ø	CH_3	27.0(150°)	>170	>22.6[e]

[a] Nmr spectra were recorded on 100 Mc spectrometer using Hexachlorobutadiene as solvent. [b] For the calculation of K at Tc, $\Delta\nu$ value at the higher temp was employed. [c] The spectrum was recorded in 1-chloronaphthalene, since in hexachlorobutadiene $\Delta\nu$ = 1cps. [d] Calculated by setting T_c = 200°. [e] Calculated by setting T_c = 170°; extensive decomposition took place above 170°.

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