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NMR STUDY OF TAUTOMERISM IN SUBSTITUTED 2-CHLOROBENZIMIDAZOLES.

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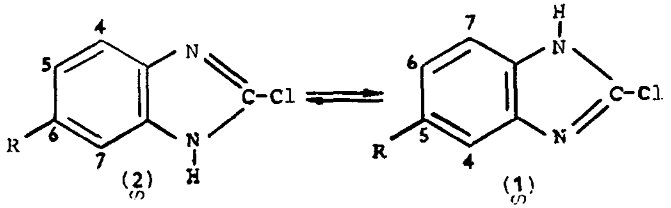
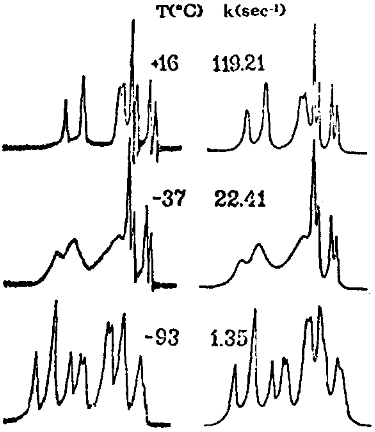
Previous studies[1] on the spectroscopic and chemical behaviour of substituted 2-chlorobenzimidazoles have shown that the two heterocyclic nitrogens are equivalent, and this has been attributed to the rapid proton exchange; however, this obviously does not hold for the corresponding N-substituted derivatives.[2] Recent results[3] reported for benzotriazoles prompted us to study tautomerism in some substituted 2-chlorobenzimidazoles (see Scheme) in connection with our previous studies on these systems. Spectra were recorded at different temperatures in THF solution, the solvent being carefully dried on a sodium mirror.[4]



I:R=OCH$_3$; II:R=H

Scheme



Figure

Only in the case of compound (I) has a temperature dependent spectrum been observed with a coalescence temperature around -35°, while for compound (II) a broadening of the spectrum starts at -100° and freezing of the solution prevented further slowing down of temperature.

Some experimental (left side) and calculated (right side) spectra for compound (I) are reported in the Figure. The total line shape method[5] has been employed with tentative exchanging rates. The relaxation time T_2 was derived from the width at half-height of peaks not broadened by exchange, and the relative amounts of tautomers (1) and (2) (p_1 and p_2) were derived from the spectra at low temperature. The amounts of tautomers (1) and (2) were slightly changed in function of temperature according to the equations[6] $\Delta G = -RT\ln K$ ($K = p_1/p_2$; $\Delta G_{189} = 0.22$ kcal./mole). The activation energy E_a was derived by an Arrhenius plot, and for the free energy of activation (ΔG^*) the transmission coefficient was taken as being equal to 1.

$$E_a = 4.25 \pm 0.11 \text{ kcal./mole}; \quad \log A = 5.29 \pm 0.11 \text{ sec.}^{-1}$$

The error on E_a and on the frequency factor was obtained by a least squares treatment of the Arrhenius plot, and thermodynamic quantities (at 198°K) by standard equations.[6]

$$k = 4.12 \text{ sec.}^{-1}; \ \Delta G^* = 10.91 \text{ kcal./mole}; \Delta S^* = -35.48 \text{ e.u.}; \ \Delta H^* = 3.86 \text{ kcal./mole}$$

The line shape of the N-H proton is also temperature dependent, but it was not employed since it is too sensitive to solvent effects; solvent-solute and solute-solute associations in fact modify the line shape of this signal.

We observe that in the compound here examined the frequency factor has a small value and that consequently the entropy of activation is highly negative. This should be connected with a highly ordered transition state, which may involve a polymeric structure of the compound with the nitrogen atoms linked by hydrogen bridges. Concentration effects play probably an important role in determining the thermodynamic parameters, and studies will be carried out to clarify this point.

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3) A.N.Nesmeyanov, V.N.Babin, L.A.Fedorov, M.I.Rybinskaya and E.I.Fedin, Tetrahedron, 25, 4667, 1969.

4) Spectra were recorded with a JEOL-JNMC-60HL spectrometer and temperature calibration was made with a sample of absolute methanol and standard chemical shift-temperature correlations. The samples, containing a small amount of TMS as an internal standard, were sealed under vacuum.

5) G.Binsch, J.Am.Chem.Soc.,91, 1304, 1969; Quantum Chemistry Program Exchange, University of Indiana, Bloomington, Indiana. QCPE Program n.140. The program was slightly modified to be employed on a CDC 6600 equipped with a Benson plotter.

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