Tautomerism in 3-Ethoxy-5-phenyl-1,2,4-triazole

William M. Litchman

Chemistry Department, University of New Mexico,
Albuquerque, New Mexico 87131
Received September 9, 1981

The cmr spectrum of the title compound was observed at several temperatures and assigned based on a tautomeric exchange requiring that the N(1)-H compound be present to the extent of 70%.

Because of the interest in tautomerism in nitrogen heterocycles evinced in recent years by the appearance of a monograph of the subject (1), it is appropriate that some recent work showing the tautomerism of 3-ethoxy-5-phenyl-1,2,4-triazole, I, be communicated. During a broader study of a variety of nitrogen heterocycles, I was observed to exhibit tautomerism with a rate detectable by nmr.
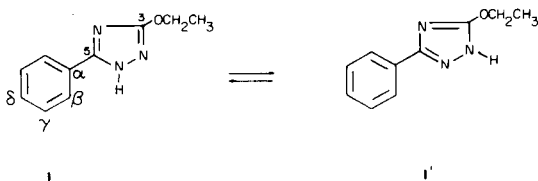

Table I presents the cmr data obtained for I and I' at 29° and 50°. The third tautomer, N(4)-H, is not included since the data indicated only two forms are observable and for several systems, the N(4)-H form is the least stable (1). With rapid tautomerism, 8 peaks should be observed and at 50°, 7 peaks are readily apparent. As the temperature is lowered, the peaks at 167.8, 153.4, and 65.1 ppm all separate into two peaks (each) unequal in height and two additional peaks appear at 131.7 and 127.3 ppm.

The peak at 65.1 ppm in the 50° spectrum is assigned to the methylene carbon and the peak at 14.3 ppm to the methyl carbon. Because of the directly bonded oxygen, the peak at 167.8 ppm is assigned to the triazole ring C-3 position and the peak at 153.4 ppm is assigned to C-5. The remaining three peaks are assigned to *delta* (128.9 ppm),

based on the intensity being one-half of the remaining two peaks, *gamma* (128.7 ppm), and *beta* (125.4 ppm) based on several examples in the literature (2). Only one carbon resonance is missing, that being *alpha* but the two small peaks appearing at low temperature provide the missing information. The *alpha* peak is obscured by the two peaks at 128.9 and 128.2 ppm.

At low temperature, some small, temperature-induced shifts can be seen for all but four resonances. For each of these latter resonances, two separate peaks are formed which are, in each case, unequal in area. The two peaks at 168.2 and 161.2 ppm (29°) are related to the peak at 167.8 ppm (50°) and are assigned to C-3 and C-3', respectively. This assignment is supported, in part, by the upfield effect a hydrogen on a neighboring nitrogen has on a carbon shift in the pyrazole ring (3). In the case of pyrazole, the upfield shift produced by this structural change is 10.4 ppm (4) whereas in this case it is 7.0 ppm. The two peaks at 157.9 and 152.9 ppm (29°) are related to the peak at 153.4 ppm (50°) and are assigned to C-5' and C-5, respectively. Again, an upfield shift is the basis for this assignment (5.0 ppm). The relative sizes of C-3' and C-3 as well as those of C-5' and C-5 allow the assignment of the peaks at 66.5 and 64.7 ppm to the methylene carbons in I' and I, respectively.

From the relative intensities of each of the methylene, C-3, and C-5 pairs of peaks, it is found that the ratio of I to I' is 70 to 30. Peak intensities were determined by multiplying the peak height by the width of half-height. Comparisons of tautomer concentrations were made by finding the ratio of the intensities of similar peaks in each

Table I

Carbon-13 NMR Data for 3-Ethoxy-5-phenyl-1,2,4-triazole (a)

	C-3	C-3'	C-5'	C-5	*alpha'*	*delta*	*gamma*	*alpha*	*beta*	-CH₂'	-CH₂	-CH₃
at 29°	168.2 (275)	161.2 (114)	157.9 (135)	152.9 (305)	131.7 (165)	129.8 (484)	128.7 (1812)	127.3 (461)	125.6 (1896)	66.5 (186)	64.7 (460)	14.6 (1560)
at 50°	167.8 (b)		153.4 (b)			128.9	128.2		125.4		65.1 (b)	14.3

(a) All shifts are in ppm downfield from TMS (obtained by adding 40.4 ppm to the DMSO resonance as an internal standard). Numbers in parentheses are relative peak heights. Intensities used in the text are based on peak height times width at half height. (b) The calculated positions for these peaks (based on peak intensities, see experimental section) are: 166.1, 154.4, and 65.2 ppm. The calculated position for *alpha* is 128.6 ppm (obscured by *delta* and *gamma*) in the 50° spectrum.

tautomer. Thus, the heterocyclic ring C-3 peak was used in I and I' to find the relative amount of the two tautomers in the sample at 29°. Since the relaxation times and NOE of the methylene carbons in I and I' should be very similar, if not absolutely identical, the relative abundances for the two tautomers should be accurate. Thus, the usual caution (5) regarding partial saturation in comparing peak intensities of two carbons in a cmr spectrum need not be applied in this case. The same will be true of the heterocyclic

ring carbons except it is not so clear that the exchanging proton might not contribute differently to the relaxation times in the two tautomers, thus leading to a slightly different relaxation time for C-3 in I as opposed to I'. However, since the relative amounts of the two tautomers calculated from the ring peaks match those found by using the methylene peaks, within 1%, it is apparent that differences in saturation are not great enough to be of importance.

Finally, the peaks at 131.7 and 127.3 ppm can be assigned to *alpha* in I' and I, respectively, and, even though it is difficult to obtain an accurate measure of relative areas, due to overlapping neighboring peaks, the peak heights reflect the greater abundance of I. Thus, the equilibrium constant for the equilibrium represented by I and I', above, $K_T = 0.43 = [I']/[I]$.

EXPERIMENTAL

All samples were prepared from material supplied by Professor E. P. Papadopoulos (Chemistry Department, University of New Mexico, Albuquerque, New Mexico 87131) by dissolving the solute in normal (non-deuterated) DMSO to the point of saturation. The sample was then placed in a modified 10 mm pyrex test tube, placed inside of a normal 12

mm nmr sample tube with an inter-annular layer of deuterium oxide used for locking purposes. Thus, the solvent appeared as a single decoupled resonance line (assumed to be at 40.4 ppm relative to TMS). All chemical shift measurements were made relative to that internal solvent line. No corrections were made as a result of temperature shifts of the locking signal (6).

Spectra were gathered utilizing a sweep width of +/- 3000 Hz by means of a quadrature phase detection method and broad-band proton decoupling on a Varian XL-100-15 nmr spectrometer and a Nicolet TT-100 FT data system (7). Temperature control at 50° was by means of a Varian controller and at 29° by the ambient probe temperature. One thousand pulses were used in the gathering of the data and a pulse angle of 30° was used with a 1.36 second acquisition time. No additional delay time was used.

Calculated peak positions given in the note in Table I were determined by a weighted average of the positions given in the 29° spectral data.

REFERENCES AND NOTES

(1) J. Elguero, C. Marzin, A. R. Katritzky and P. Linda, "The Tautomerism of Heterocycles", Supplement 1, Advances in Heterocyclic Chemistry, Academic Press, New York, 1976.

(2) M. Bergtrup, *Acta Chem. Scand.*, **27** 3101 (1973).

(3) M. T. Chenon, C. Coupry, D. M. Grant and R. J. Pugmire, *J. Org. Chem.*, **42**, 659 (1977).

(4) W. M. Litchman, *J. Am. Chem. Soc.*, **101**, 545 (1979).

(5) J. N. Schoolery, *Prog. NMR Spectros.*, **11**, 79 (1977).

(6) W. M. Litchman and D. R. McLaughlin, *Chem. Phys. Letters*, **22**, 424 (1973).

(7) Acknowledgements are extended to the NSF (Grant MPS75-06111) for partial support of this work through purchase of the Nicolet TT-100 data acquisition system. Thanks are also extended to Professor E. P. Papadopoulos for supplying the compound studied in this work and to a referee for several helpful suggestions.