

The Structure of N,N,N'' -Trisubstituted Formamidrazones

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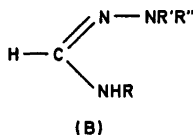
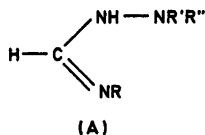
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In connection with the preparation of N,N,N'' -trisubstituted formamidrazones from the reaction between isocyanides and N,N -disubstituted hydrazines¹ it was of interest to determine the structure of the formamidrazones.

The structure of amidrazones with the possibility of tautomerism has recently been discussed,²⁻⁵ mainly on basis of IR and ¹H NMR spectra. For N'' -phenyl substituted formamidrazones these spectra do not always give conclusive evidence, whereas ¹³C NMR spectra may be of some use.

This paper reports the application of ¹³C and ¹H NMR spectroscopy for distinguishing between the amide hydrazone structure (B) and hydrazone imide form (A) in some trisubstituted amidrazones and a discussion of the number of conformers present on basis of IR and NMR measurements.

Results. The ¹³C NMR spectra of the formamidrazones (1-4, Table 1) and of some model substances (δ -8) were obtained in CDCl₃-solution.

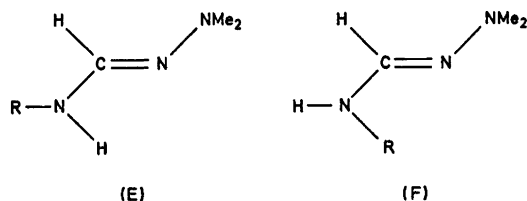
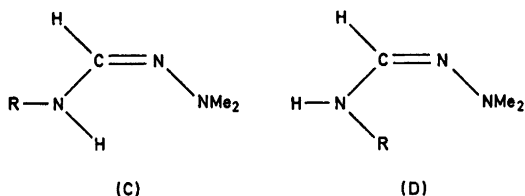


The chemical shift values of the quaternary ring carbon atom for R=phenyl, and the tertiary carbon atom in the CN double bond are those most influenced by the position of the NH hydrogen atom. From Table 1 it is evident that the chemical shift values for the carbon atom in the CN bond are 152-155 ppm for compounds with the CN bond in conjugation with the benzene ring. For the same compounds the quaternary ring carbon atom shows chemical shift values of approximately 152 ppm. For the formamidrazones 1 and 2 the corresponding signals are found at 146-148 ppm and 139 ppm, respectively, indicating a structure different from the hydrazone imide structure (A).

The signal pattern from the tertiary phenyl carbon atoms supports our assumption that the structure of compounds 1 and 2 is (B) and not (A). For compounds with the benzene ring in conjugation to the CN-double bond the chemical

shift value of the *ortho*-carbon atoms was approximately 6 ppm low-field compared with the values for compounds 1 and 2, while the values for *meta*- and *para*-carbon atoms were almost identical.

To estimate the position of the NH hydrogen atom in 3, (R=cyclohexyl), the ¹H NMR (60 MHz) spectrum was used. At room temperature in CDCl₃ the CH=N proton signal was a broad doublet δ 6.88 (collapsed on shaking with D₂O), and the NH signal was broad δ 5.1-5.8 (disappeared on shaking with D₂O). At -50 °C the NH-proton showed four signals of equal intensity due to coupling with both the cyclohexyl CH and the imino CH (J_{NHCH} 9 Hz resp. 12 Hz, δ 5.55). These data indicate that compound 3 exists in form (B).



To distinguish between the possible forms (C-F) of tautomer (B) the IR and NMR data were compared. In chloroform solution the IR spectra of the formamidrazones showed weak to medium NH-stretching absorptions around 3365 and 3260 cm⁻¹, absorptions which did not change in relative intensity on dilution, indicating no intermolecular hydrogen bond.

The ¹³C NMR spectra obtained in CDCl₃ at room temperature and -55 °C showed only one set of signals for compound 1 and 3, indicating the presence of only one isomer in accordance with IR data.

In tetrachloromethane and benzene solution the IR spectra were different from those in chloroform showing concentration dependence of the NH stretching absorption at lowest wavenumber. The absorption disappeared on dilution, indicating the presence of an intermolecular hydrogen bond, which seems impossible in form (C).

¹H NMR (270 MHz) of 1 (21 and -20 °C) in CCl₄ showed two singlets for the methyl groups at δ 2.49 and 2.39 (intensity 1/5), the CHN proton was one broad singlet at δ 7.39, which sharpened on shaking with D₂O. The NH signal

Table 1. ^{13}C Chemical shift values (δ values).

Compound	-NH-CH=N- Carbon atom	Ring carbon atom			
		Quaternary	meta	para	ortho
PhNHCHNNMe ₂	(1) 145.8	139.8	129.6	122.1	115.5
PhNHCHNNEt ₂	(2) 148.2	139.2	129.0	121.5	114.5
C ₆ H ₁₁ NHCHNNMe ₂	(3) 149.5				
PhNCHN(Me)NMe ₂	(4) 154.7	151.8	128.9	122.6	121.3
PhNCHNMe ₂ ⁶	(5) 153.4	152.2	128.9	122.2	121.1
PhNCHNEt ₂ ⁶	(6) 152.2	152.2	128.8	122.1	121.1
PhNC(NMe ₂) ₂ ⁷	(7) 159.0	152.0	128.4	121.5	119.6
PhNCHNHMe	(8) 151.6	151.6	129.0	122.7	121.1

was broad around δ 7.7. For compound 3 (21 °C, CCl₄) the methyl signal consisted of two singlets at δ 2.25 and 2.28 (intensity 3/1), the CHN proton was a doublet centered at δ 6.62 and the NH proton a broad signal around δ 5.4. On cooling to -20 °C the NH signal sharpened to four signals of equal intensity as in the CDCl₃ solution.

Discussion. The determination of the tautomer as (B) is in accordance with results on basis of IR measurements.³ In chloroform solution it seems reasonable to conclude that the configuration is (C) because of the position of the NH-stretching absorption, its independence of dilution and the presence of only one set of lines in the ^{13}C NMR spectra. Other formamidrazones³ have been shown to exist as equilibrium mixtures of (C) and (D) forms in solution, with coalescence temperature above 0 °C. The compounds investigated here show no doubling of NMR signals on cooling to -55 °C why the existence of an equilibrium mixture of (C) and (D) in chloroform solution seems less probable.

In CCl₄ solution the presence of two methyl signals in the ^1H NMR spectra for compounds 1 and 3 indicates the presence of two forms. According to the IR spectra this must be one form with intermolecular and one structure with intramolecular hydrogen bond. Since the presence of both an *E*- and a *Z*-isomer [*e.g.* forms (C) and (E)] possibly would have given rise to two CH=N signals in the NMR spectra (both in CDCl₃ and CCl₄) it seems reasonable to conclude that the two forms present in CCl₄ are the forms (C) and (D).

Experimental. ^1H NMR spectra (270 MHz) were recorded on a Bruker HX-270 S apparatus, concentration 100 mg/ml. ^{13}C NMR spectra were recorded on a Bruker WH 90 apparatus, concentration 300 mg/ml. For other experimental details see Ref. 1.

N¹-Methyl-N³-phenylformamidine (8) was prepared by refluxing equimolar amounts (0.1 mol) of aniline hydrochloride, *N*-methylformamide and *p*-toluenesulfonyl chloride in 100 ml of benzene for 24 h. The solution was made alkaline

with 50 % NaOH, extracted with benzene, the benzene layer evaporated to dryness and the residue recrystallized from benzene. Yield 60 %, m.p. 88–89 °C. Anal. C₉H₁₀N₂: C, H, N. ^1H NMR spin decoupling experiments at -50 °C proved the position of the NH hydrogen atom to be adjacent to the methyl group.

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