

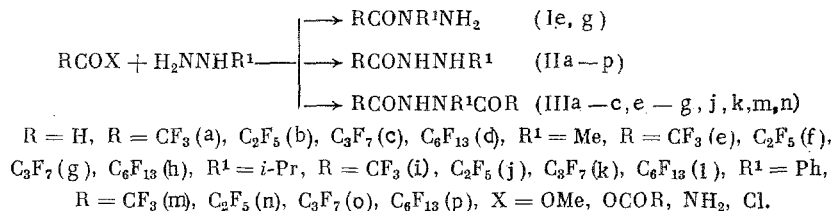
I. D. Kalikhman, E. N. Medvedeva, D. F. Kushnarev,
T. I. Yushmanova, and V. A. Lopyrev

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The problem of the selective acylation of two nonequivalent nitrogen atoms in a substituted hydrazine is of practical and theoretical interest. The acetylation of methyl- [1] and other alkylhydrazines [2] has been studied the most. The data on the acylation of substituted hydrazines using perfluorocarboxylic acid derivatives is both limited and contradictory. For instance, the product of the acylation of methylhydrazine with ethyl trifluoroacetate has been erroneously described in [3] as 1-trifluoroacetyl-1-methylhydrazine.

We have shown [4] that methylhydrazine reacts with perfluorocarboxylic acid derivatives mainly at the unsubstituted nitrogen atom to form 1-acyl-2-methylhydrazines.

In the present work the structure and the conformational properties of NMe-, *i*-Pr-, and Ph-perfluoroacylhydrazines as well as of diacylhydrazines have been investigated using ¹⁹F NMR. These compounds were prepared using the reaction



The structure and conformational properties of 1-acyl-2-methylhydrazines (IIe, g) have been investigated in [5]. The 1-acyl-1-methylhydrazines (Ie, g) were only successfully detected in amounts of 1% or less in the products of the acylation of methylhydrazine with anhydrides of perfluorocarboxylic acids (R = CF₃, C₃F₇) in solvents of the amine type. Attempts to isolate them in a pure form were unsuccessful. The ¹H and ¹⁹F NMR parameters of the isomers (I) were obtained from the spectra of a mixture of (I), (II), and (III) and are shown in Table 1. The isomers (I) and (II) of the MeN derivatives differ in the position of their MeN signals by more than 0.5 ppm [5]. However, there are no reliable differences in the ¹H NMR spectra of other N-acyl- and N-phenyl-acylhydrazines. In this case, the ¹⁹F NMR spectra turn out to be the most informative (Table 2). With respect to their ¹⁹F chemical shift values, N-isopropyl- and N-phenylhydrazines are similar to the N-methylhydrazides for which the structure (II) has been established. Consequently, these derivatives are also the 1,2-isomers. Additional confirmation is provided by an analysis of the ¹⁹F chemical shifts of diacylhydrazines (III) (Table 3), where the perfluoroacyl groups at NH and NMe differ in their ¹⁹F chemical shifts by 5-6, 0.7-1.0, and 0.5 ppm in the α, β, and γ positions, respectively. We were unable to detect the 1,1-isomer (I) in the products of the acylation of isopropyl- and phenylhydrazine.

TABLE 1. ¹H and ¹⁹F NMR Parameters of RCONMeNH₂ Compounds (10% solutions in CDCl₃).

| Compound | R | Rotamer | δ, ppm | | | | ⁴ J _{HF} , Hz |
|----------|-------------------------------|----------|--------|-----------------|-------------------|-------------------|-----------------------------------|
| | | | Me | CF ₃ | α-CF ₂ | β-CF ₂ | |
| (Ie) | CF ₃ | <i>E</i> | 3.24 | 70.5 | — | — | 1.2 |
| | | <i>Z</i> | 3.32 | 70.7 | — | — | 1.4 |
| (Ig) | C ₃ F ₇ | <i>E</i> | 3.18 | 81.9 | 111.1 | 124.7 | 1.0 |
| | | <i>Z</i> | 3.25 | 82.3 | 118.8 | 127.2 | 1.2 |

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TABLE 2. ^{19}F NMR Chemical Shifts of RCONHNHR^1 Compounds (10% solutions in DMSO)

| R ¹ | Compound | R=CF ₃ | Compound | R=C ₆ F ₁₃ | | | |
|----------------|----------|-------------------|----------|----------------------------------|-------------------|-------------------|-----------------|
| | | | | α-CF ₂ | β-CF ₂ | γ-CF ₂ | CF ₃ |
| H | (IIa) | 75,3 | (II d) | 120,2 | 124,2 | 128,2 | 83,0 |
| Me | (IIe) | 75,8 | (II h) | 119,8 | 124,2 | 128,1 | 82,9 |
| <i>i</i> -Pr | (IIi) | 75,6 | (II l) | 119,6 | 124,8 | 128,2 | 82,9 |
| Ph | (II m) | 76,2 | (II p) | 120,8 | 124,5 | 128,1 | 82,9 |

| R ¹ | Compound | R=C ₂ F ₅ | | Compound | R=C ₃ F ₇ | | |
|----------------|----------|---------------------------------|-----------------|----------|---------------------------------|-------------------|-----------------|
| | | α-CF ₂ | CF ₃ | | α-CF ₂ | β-CF ₂ | CF ₃ |
| H | (IIb) | 123,9 | 84,9 | (II c) | 120,9 | 128,6 | 82,4 |
| Me | (II f) | 123,1 | 84,6 | (II g) | 120,9 | 129,2 | 82,4 |
| <i>i</i> -Pr | (II j) | 123,0 | 84,6 | (II k) | 120,5 | 128,4 | 82,9 |
| Ph | (II n) | 124,0 | 84,9 | (II o) | 122,0 | 128,9 | 82,5 |

TABLE 3. ^{19}F NMR Chemical Shifts of RCONHNRCOR Compounds (10% solutions on CDCl₃)

| R ¹ | Population, % | Compound | R=CF ₃ | | Compound | R=C ₂ F ₅ | |
|----------------|---------------|----------|----------------------------|-----------------|---------------|---------------------------------|-----------------|
| | | | CF ₂ | CF ₃ | | CF ₂ | CF ₃ |
| H | 100 | (IIIa) | 75,9 & 75,9 | (III b) | 124,0 & 124,0 | 84,2 & 84,2 | |
| Me | 80 | (III e) | 72,7 & 76,3 | (III f) | 118,9 & 124,3 | 83,3 & 84,0 | |
| | 20 | | 71,8 & 76,1 | | 117,9 & 124,4 | 83,8 & 84,2 | |
| <i>i</i> -Pr | 90 | (III m) | 72,4 & 75,9 69,0 & 75,6 | (III l) | 118,9 & 123,5 | 83,1 & 84,1 | |
| | 10 | | | | 117,6 & 123,8 | 83,3 & 84,1 | |
| Ph | 60 | | | | 119,2 & 124,3 | 83,3 & 84,3 | |
| | 40 | | | (III n) | 115,0 & 124,2 | 83,4 & 84,3 | |

| R ¹ | Population, % | Compound | R=C ₃ F ₇ | | |
|----------------|---------------|----------|---------------------------------|-------------------|-----------------|
| | | | α-CF ₂ | β-CF ₂ | CF ₃ |
| H | 100 | (III c) | 121,5 & 121,5 | 128,0 & 128,0 | 82,5 & 82,5 |
| Me | 80 | (III g) | 115,8 & 121,8 | 127,0 & 128,6 | 81,7 & 82,3 |
| | 20 | | 115,2 & 122,1 | 127,2 & 128,4 | 81,5 & 82,3 |
| <i>i</i> -Pr | 90 | (III k) | 115,6 & 120,8 | 126,4 & 127,9 | 81,1 & 81,7 |
| | 10 | | 114,4 & 121,2 | 126,7 & 127,9 | 81,0 & 81,7 |
| Ph | 60 | | | | |
| | 40 | | | | |

Only a single group of signals is observed in the spectra of 1-acyl-2-methylhydrazines as well as in their isopropyl and phenyl analogs (IIIi-p). Apparently, all the compounds (II) have the Z conformation, which is stabilized by intramolecular hydrogen bonds [6]. The conformational assignment in (I) (see Table 1) was carried out on the basis of the well-known regularities in the PMR spectrum of N,N-dimethyltrifluoroacetamide [7]. The signals due to MeN in a cis position to the C=O group lie at stronger field than those for MeN in trans position and $^5J_{\text{HF-cis}} > ^5J_{\text{HF-trans}}$.

Four conformers may be proposed for the diacylhydrazines (III) which take account of the frozen rotation about the N-CO bond and free rotation about the N-N bond.

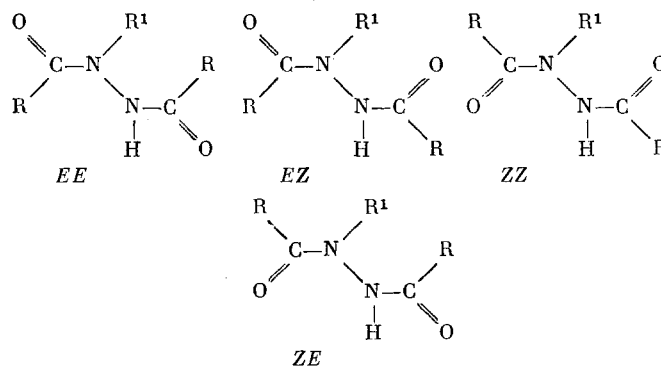


TABLE 4. 1-Perfluoroacyl-2-alkyl(phenyl)hydrazines RCONHNHR¹ (II) and 1,2-Di(perfluoroacyl)-1-alkyl-(phenyl)hydrazines RCONNH₂CO₂R¹ (III)

| Compound | Yield, % | mp, °C | Found, % | | | Empirical formula | Calculated, % | | |
|----------|----------|----------------------|----------|------|-------|--|---------------|------|-------|
| | | | C | H | N | | C | H | N |
| (III) | 82 | 85 ^a | 35.25 | 5.28 | 16.39 | C ₆ H ₅ F ₃ N ₂ O | 35.30 | 5.34 | 16.55 |
| (IIIm) | 97 | 132-133 ^b | 47.22 | 3.63 | 43.66 | C ₆ H ₅ F ₃ N ₂ O | 47.06 | 3.43 | 43.73 |
| (IIl) | 64 | 61-62 ^a | 25.19 | 2.49 | 14.50 | C ₇ H ₅ F ₃ N ₂ O | 25.01 | 2.62 | 14.58 |
| (IIl) | 77 | 79-80 ^a | 32.62 | 4.04 | 12.75 | C ₆ H ₅ F ₃ N ₂ O | 32.74 | 4.12 | 12.72 |
| (IIl) | 79 | 118 ^b | 42.36 | 2.78 | 11.06 | C ₆ H ₅ F ₃ N ₂ O | 42.53 | 2.78 | 11.02 |
| (IIl) | 89 | 75-76 ^a | 31.25 | 3.53 | 10.31 | C ₇ H ₅ F ₃ N ₂ O | 31.11 | 3.33 | 10.37 |
| (IIo) | 94 | 129-130 ^b | 39.60 | 2.33 | 9.31 | C ₁₀ H ₇ F ₇ N ₂ O | 39.47 | 2.30 | 9.21 |
| (IIh) | 76 | 68-69 ^a | 24.50 | 4.31 | 7.24 | C ₈ H ₇ F ₃ N ₂ O | 24.51 | 4.29 | 7.14 |
| (IIl) | 72 | 71-72 ^a | 26.78 | 4.73 | 7.09 | C ₉ H ₇ F ₃ N ₂ O | 26.62 | 4.73 | 7.14 |
| (IIp) | 98 | 85-86 ^c | 34.22 | 4.36 | 6.02 | C ₁₃ H ₇ F ₁₃ N ₂ O | 34.38 | 4.55 | 6.17 |
| (IIIm) | 75 | 106 ^a | 40.43 | 2.12 | 9.32 | C ₁₀ H ₆ F ₆ N ₂ O ₂ | 40.01 | 2.02 | 9.33 |
| (IIIf) | 52 | 39-40 ^b | 24.97 | 4.14 | 8.34 | C ₇ H ₅ F ₁₀ N ₂ O ₂ | 24.87 | 4.19 | 8.28 |
| (IIIi) | 97 | 61-62 ^a | 29.52 | 2.21 | 7.65 | C ₆ H ₅ F ₁₀ N ₂ O ₂ | 29.52 | 2.21 | 7.65 |
| (IIIm) | 82 | 99 ^d | 35.97 | 4.49 | 7.10 | C ₁₂ H ₆ F ₁₀ N ₂ O ₂ | 36.02 | 4.51 | 7.00 |
| (IIIg) | 92 | 51-52 ^e | 24.64 | 4.04 | 6.38 | C ₉ H ₅ F ₁₀ N ₂ O ₂ | 24.66 | 4.04 | 6.39 |
| (IIIk) | 85 | 51-52 ^a | 28.35 | 4.74 | 6.01 | C ₁₁ H ₅ F ₁₄ N ₂ O ₂ | 28.34 | 4.73 | 6.01 |

^a Vacuum sublimation. ^b From water. ^c From hexane. ^d From benzene. ^e Reprecipitation from ethanol by water.

Only a single group of signals (see Table 3) is observed in the ^{19}F NMR spectra of the diacylhydrazines with $\text{R} = \text{H}$ (IIIa-c). This means that the EZ and ZE conformations with non-equivalent RCO groups may be precluded from further consideration. Of the symmetric conformations, it follows that preference should be given to the ZZ conformation in which the conditions for the intra- and intermolecular hydrogen bonding of the $\text{NH}\dots\text{O}=\text{C}$ groups are more favorable. Two conformers are observed from the spectra of the N-substituted diacylhydrazines (IIIe-g, j, k, m, p). According to [5], the EZ conformer is the more populated and the ZZ conformer, the lesser populated. The population of the ZZ rotamer is reduced in 1,2-diacyl-1-isopropylhydrazines, while in the N-phenyl analogs it is increased in comparison with 1,2-diacyl-1-methylhydrazines. This difference is apparently due to the competing steric interactions between the R^1 group and the R and C=O groups.

EXPERIMENTAL

The ^1H and ^{19}F NMR spectra were recorded on Tesla BS 487-C and Varian XL-100A spectrometers. ^{19}F Chemical shifts were measured with respect to a PhCF_3 internal standard and are cited relative to CFCl_3 .

The purity of the preparations was controlled and the reaction mixtures were analyzed by means of thin-layer chromatography on Silufol UV-254 plates (chloroform:ethanol = 7:1 or butanol:water:AcOH = 4:5:1).

The compounds (II) were prepared by mixing equimolar amounts of the perfluorocarboxylic acid ester and the substituted hydrazine in absolute methanol. Compounds IIIa-c, e, g were prepared according to [5, 8] and IIe, h are described in [4]. Compounds IIIf, g, j, k, m, n were synthesized using the following technique.

Pyridine (0.02 mole) was added to a solution of 0.02 mole of hydrazide (II) in absolute dioxane or CHCl_3 , followed by the slow dropwise addition of a solution of 0.02 mole of the corresponding perfluoroacylchloride in the same solvent (the trifluoroacetyl fluoride was passed into the solution in the form of a gas). The mixture was boiled for 7 h and then poured out into ice water. The precipitate was filtered off and washed with water.

The properties of the new compounds are presented in Table 4.

In searching for the optimal conditions for the synthesis of (I), substituted hydrazines were acylated with esters, amides, and the anhydrides and chloroanhydrides of perfluorocarboxylic acids. According to the NMR and gas-liquid chromatographic data, a mixture of (I) (1%), (II) (94%), and (III) (5%) was obtained when methylhydrazine was acylated with trifluoroacetic anhydride and perfluorobutyric anhydride under the conditions described in [1].

CONCLUSIONS

It has been demonstrated by means of ^{19}F NMR that 1-acyl-2-alkyl(phenyl)hydrazines are the main products of the monoacylation of alkyl- and phenylhydrazine with derivatives of perfluorocarboxylic acids. The preferred conformations with respect to the amide bond have been determined in mono- and di(perfluoroacyl)hydrazines.

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