HETEROCYCLIC ANALOGS OF PLEIADIENE. 41.* SYNTHESIS OF 2-PERFLUOROALKYL-PERIMIDINES

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2-Perfluoroalkylperimidines were obtained by the action of trifluoroacetic anhydride and perfluoro carboxylic acid chlorides on 1,8-naphthalenediamine and its N-substituted derivatives. N,N'-Diacyl-1,8-naphthalenediamines (in the case of unsubstituted 1,8-naphthalenediamine) and 6(7)-perfluoroacyl-2-perfluoroalkylperimidines (in the case of N-substituted 1,8-naphthalenediamines) were isolated as side products.

2-Perfluoroalkylperimidines were previously unknown. In order to obtain them, in the present research we studied the reaction of 1,8-naphthalenediamine (I) with derivatives of perfluoro carboxylic acids. A mixture of difficult-to-separate compounds in which 2-trifluoromethylperimidine (V) is absent is formed when diamine I is heated with excess trifluoroacetic acid. However, cyclization to give V in 93% yield occurs in the reaction with trifluoroacetic anhydride in the cold. N,N'-Bis(trifluoroacetyl)-1,8-naphthalenediamine (VI), the structure of which was confirmed by IR data and mass spectroscopy, is a side product (in 6% yield). Amide VI is not converted to perimidine V when it is heated with mineral acids or alkalis and thus is not an intermediate in its formation (see the data on other N,N'-diacyl derivatives of I [2]). The formation of V undoubtedly proceeds through a step involving monoacyl derivative IV. In fact, we obtained the latter by acylation of diamine I with an equimolar amount of trifluoroacetic anhydride in chloroform at 0-5°C. This compound is rapidly converted to perimidine V when it is heated to 85°C.

N-Substituted 2-trifluoromethylperimidines cannot be obtained by direct alkylation of V through its silver salt, by methylation with diazomethane (the yield of methyl derivative VII is only 1%), or by alkylation of the anion of V under the normal conditions for the alkylation of perimidines [3]. It should be noted that although the N anion of 2-trifluoromethylperimidine is not alkylated under various conditions (evidently because of a pronounced decrease in the negative charge on the nitrogen atoms due to the inductive effect of the CF_3 group), like the anion of perimidine itself [3], it is very readily oxidized in air to give a black resinous substance.

1-Substituted 2-trifluoromethylperimidines VII and VIII were obtained in good yields by the action of trifluoroacetic anhydride on N-methyl- and N-phenyl-1,8-naphthalenediamine (II, III). Trifluoroacetyl derivatives (IX and X) of VII and VIII rather than N,N'-diacyl derivatives of the starting diamine were somewhat unexpectedly isolated as side products. The formation of such side products in the case of diamines II and III evidently proceeds with greater difficulty because of the steric hindrance created by the substituent attached to the nitrogen atom of the second entering acyl group.

The structures of IX and X are confirmed by the results of elementary analysis and the IR spectra ($\nu_{C=O}$ 1690 cm^{-1}), as well as by the PMR spectra, which are characteristic for 6- and 7-acylperimidines [4]. The principal peculiarity of the PMR spectra of the latter is the low-field shift of the signal of the peri proton as a result of its magnetic deshielding by the carbonyl oxygen atom. However, the PMR spectra do not make it possible to choose between the 6- and 7-substituted structures. We assigned the 7-substituted structure to IX and X on the basis of the following reasoning.

*See [1] for communication 40.

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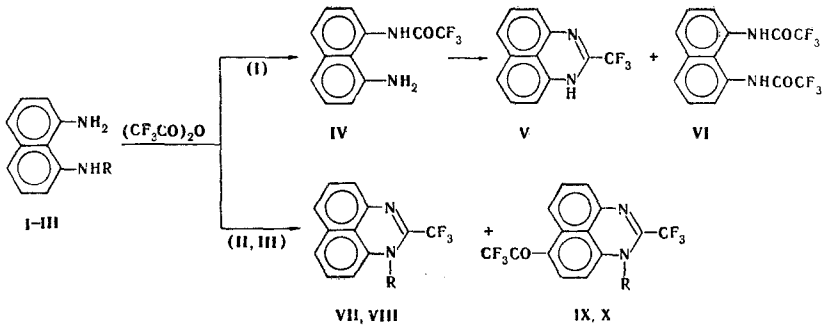
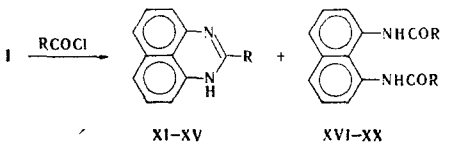


I R=H; II, VII, IX R=CH_3; III, VIII, X R=C_6H_5

They can be obtained in high yield by the direct trifluoroacetylation of VII and VIII with trifluoroacetic anhydride. This reaction proceeds exceptionally selectively, but this selectivity is not observed in the acylation of perimidines with carboxylic acids in polyphosphoric acid (PPA) [4]. Perimidine itself and 1-methylperimidine are not acylated by trifluoroacetic anhydride, despite the fact that it would seem that they should be acylated more readily than their 2-trifluoromethyl derivatives. These facts, which will be discussed in detail in our next communication, constitute evidence that IX and X are acylated in the form of neutral molecules (because of the reduced basicity), while perimidine and 1-methylperimidine are acylated in the cationic form and therefore undergo acylation with greater difficulty and less selectively (the electron densities in the 6 and 7 positions of the cation are equalized) [4]. Since substantially greater negative charge is found in the 7 position than in the 6 position in the neutral 1-methylperimidine molecule [4], it may be assumed that the reaction proceeds primarily in the 7 position. Even greater charge is found in the 9 position; however, it is known [4] that substituents attached to the nitrogen atom completely suppress acylation in the 9 position.

A characteristic feature of the PMR spectrum of N-phenyl-substituted X is the unusually pronounced paramagnetic shift of the signal of the 9-H proton. In the case of a solution in trifluoroacetic acid it appears in the form of a doublet at δ 5.55 ppm (J_{ortho} = 9 Hz), while it is observed at 6.70 ppm (J_{ortho} = 8.3 Hz) in the spectrum of N-methyl-substituted IX under the same conditions. Similarly, the 9-H proton gives a doublet at 5.77 ppm in the PMR spectrum of 1-phenylperimidine. On the basis of this, it may be concluded that because of steric hindrance on the side of the 9-H proton, the N-phenyl group in perimidines deviates extremely from the plane of the heterosystem, as a result of which this proton is shielded by the paramagnetic component of the ring current of the phenyl ring. It is also interesting to note that the signal of the 9-H proton in 1-phenylperimidine does not appear in the form of a quartet, as in the case of 1-alkylperimidines [5], but rather in the form of a doublet with J_{ortho} = 7.5 Hz. A similar decrease in the J_{meta} constant to zero has also been noted in other cases for magnetic coupling of one of the protons of the ABX system with an adjacent group [see, for example, the data for the peri proton in 6(7)-acylperimidines [4] or for the 1-H proton in 12-N-pyridiniabenz[a]anthracene [6]].

Other 2-perfluoroalkylperimidines (XI-XIV), as well as 2-pentafluorophenylperimidine (XV), were obtained in good yields (Table 1) by the action of the chlorides of the corresponding perfluorinated acids on diamine I. Diacyl-1,8-naphthalenediamines XVI-XX are formed in low yields as side products in all of these reactions.



XI, XVI R=n-C_4F_9; XII, XVII R=n-C_6F_{13}; XIII, XVIII R= perfluorocyclohexyl; XIV, XIX R= perfluorotetrahydrofurfuryl; XV, XX R=C_6F_5

Like perimidines themselves, 2-perfluoroalkyl- and 2-pentafluorophenylpermidines are bright-yellow crystalline substances, and this makes it possible to easily distinguish them from the colorless 1,8-naphthalenediamine derivatives of the IV, VI, or XVI-XX type. Except for perimidine XIII, which darkens rapidly on storage, all of them are stable for a long time both in the crystalline state and in solution. An important property of 2-perfluoroalkylperimidines and 2-pentafluorophenylperimidine is the development of a bright-red coloration when they are dissolved in strong acids (CF_3COOH, concentrated HCl, and H_2SO_4). The development of this coloration is not observed in glacial acetic acid. The red solutions again become yellow when they are highly diluted with water. Since the color of perimidinium ions is virtually the same as the color of

TABLE 1. Products of the Reaction of 1,8-Naphthalenediamine with Derivatives of Perfluoro Carboxylic Acids (See the Formulas in the Text)

Compound	mp, deg C[a]	IR spectrum,[b] ν, cm^{-1}			Found, %			Empirical formula	Calc., %			Yield, %
		N–H	C=O	C=C, C=N	C	H	N		C	H	N	
VII	131	—	—	1590, 1635	62,3	3,6	11,1	$C_{13}H_9F_3N_2$	62,4	3,6	11,2	72
VIII	139,5—140	—	—	1585, 1635	69,2	3,5	8,9	$C_{18}H_{11}F_3N_2$	69,2	3,6	9,0	76
XI	109—110	3430	—	1605, 1648	46,3	2,0	7,2	$C_{15}H_7F_9N_2$	46,3	1,8	7,3	72
XII	94	3430	—	1605, 1650	41,7	1,7	5,8	$C_{17}H_7F_{13}N_2$	42,0	1,5	5,8	56
XIII	136—137	3430	—	1610, 1645	45,7	1,6	6,3	$C_{17}H_7F_{11}N_2$	45,6	1,6	6,3	59
XIV	104,5—105	3435	—	1605, 1645	46,3	1,5	6,8	$C_{16}H_7F_9N_2O$	46,4	1,7	6,8	68
XV	228—229	3430	—	1605, 1645	61,0	2,2	8,1	$C_{17}H_7F_5N_2$	61,1	2,1	8,4	74
XVI	179—183	3280	1715	— —	36,6	1,0	4,5	$C_{20}H_8F_{18}N_2O_2$	36,9	1,2	4,3	11
XVII	184—189	3275	1715	— —	33,5		3,0	$C_{24}H_8F_{26}N_2O_2$	33,9	0,95	3,3	2
XVIII	179—186	3285	1725	— —	37,0	1,3	3,4	$C_{24}H_8F_{22}N_2O_2$	37,2	1,0	3,6	12
XIX	169—170	3280	1715	— —	37,3	0,96	4,0	$C_{22}H_8F_{18}N_2O_2$	37,4	1,1	4,0	13
XX	269	3270	1715	— —	52,4	1,2	5,1	$C_{24}H_8F_{16}N_2O_2$	52,8	1,5	5,1	8

a) Compounds VII, VIII, and XI-XV were purified by crystallization from octane, and XVI-XX were washed with water and chloroform. Compounds XV-XX melt with decomposition. b) The IR spectra of VII, VIII, and XI-XV were obtained from solutions in $CHCl_3$, and the IR spectra of XVI-XX were obtained from suspensions in mineral oil.

the neutral molecules [5], it may be assumed that 2-perfluoroalkylperimidines in strongly acidic media are protonated at the carbon atoms of the naphthalene ring to give a colored quinoid system. We will study this problem in greater detail later.

The fluorine atoms in the CF_3 group of the perimidines are more labile than those in 2-trifluoromethylbenzimidazole [7]. Thus heating perimidine VIII with o-phenylenediamine in ethylene glycol (20 h) or the reaction of V with diamine I under the same conditions did not lead to the formation of cyclization products. The CF_3 group itself in the compounds obtained also has low lability. For example, we were unable to replace it by an amino group by the action of potassium amide on VIII in liquid ammonia, as in the case of α-triflouromethyl derivatives of azines [8].

EXPERIMENTAL

The IR spectra of the compounds were recorded with a UR-20 spectrometer. The PMR spectra of solutions of the compounds in trifluoroacetic acid were recorded at room temperature with a Tesla BS-467 spectrometer (60 MHz) with hexamethyldisiloxane as the internal standard. The UV spectra were obtained with an SF-4A spectrophotometer. The mass spectra were recorded with a Varian MAT CH_8 spectrometer.

N-Trifluoroacetyl-1,8-naphthalenediamine (IV). An equimolar amount of trifluoroacetic anhydride was added to a cooled (to 0–5°C) solution of 0.8 g (5 mmole) of diamine I in 15 ml of chloroform. The mixture became warm and turned red, and a copious precipitate formed. After 30 min, the precipitate was removed by filtration and washed with a small amount of chloroform to give 0.85 g (66%) of a colorless crystalline substance, which was rapidly converted to perimidine V when it was melted (at ~85°C). IR spectrum (in mineral oil): 3375 (N–H), 3270 (N–H), 1680 (C=O), and 1150 cm^{-1} (C–F). Found: C 56.6; H 3.6; N 11.3%. $C_{12}H_9F_3N_2O$. Calculated: C 56.7; H 3.6; N 11.0%.

2-Trifluoromethylperimidine (V) and N,N'-Bis(trifluoroacetyl)-1,8-naphthalenediamine (VI). An ice-cooled flask equipped with a dropping funnel, and ice-cooled condenser, and a calcium chloride tube was charged with 3.2 g (0.02 mole) of diamine I, and 21 g (0.1 mole) of trifluoroacetic anhydride was added dropwise. The resulting bright-red precipitate was removed by filtration the next day and dried in vacuo over calcium chloride. It was then refluxed for 30 min with 100 ml of water (if the precipitate is not dried beforehand, it forms clumps when it is refluxed with water, and the operation is unsuccessful), after which the mixture was cooled, and a yellow precipitate of a mixture of V and VI was removed by filtration. The mixture was treated with chloroform, and the insoluble white amide VI was removed by filtration to give 0.42 g (6%) of a product with mp 258-259°C (dec.). IR spectrum (in mineral oil): 3280 (N–H), 1715 (C=O), and 1175 cm^{-1} (C–F). Mass spectrum, m/e (intensity, %): 350 (100); 331 (4.1), 281 (6.8), 253 (16.2), 237 (21.6), 226 (10.8),

184 (62.2), 156 (14.9), 140 (10.8), 102 (13.5), 69 (21.6), 28 (70.3), 18 (45.9). Calculated: C 47.8; H 2.2; F 32.6; N 8.1%. $C_{14}H_8F_6N_2O_2$. Calculated: C 48.0; H 2.3; F 32.6; N 8.0%.

The chloroform solution was evaporated to give 4.3 g (93%) of perimidine V with mp 157°C (from octane). IR spectrum (in $CHCl_3$): 3430 (N–H) and 1155 cm^{-1} (C–F). UV spectrum, λ_{max}, nm (log ε): 334 (4.13) and 410 (2.98) (in methanol); 300 (4.21) and 440 (2.88) (in CF_3COOH). Found: C 61.0; H 2.9; N 11.8%. $C_{15}H_8F_6N_2O$. Calculated: C 61.0; H 3.0; N 11.8%.

1-Methyl-2-trifluoromethylperimidine (VII) and 1-Methyl-2-trifluoromethyl-7-trifluoroacetylperimidine (IX). A flask equipped with a reflux condenser and a calcium chloride tube was charged with 350 mg (2 mmole) of diamine II, and 4.2 g (20 mmole) of trifluoroacetic anhydride was added with cooling (with ice). After the exothermic reaction had ceased, the mixture was maintained at room temperature for 4-5 h. It was then diluted with water and neutralized with 10-15% ammonium hydroxide, and the light-brown crystals of perimidines VII and IX were removed by filtration. Trifluoroacetylation product IX was separated by chromatography with a column filled with aluminum oxide (Brockmann activity IV) by elution with benzene (VII had R_f 0.95, and IX had R_f 0.1). The yield of VII was 360 mg (72%); the light-yellow crystals had mp 131°C (from octane). The yield of IX was 40 mg (6%); the lemon-yellow crystals had mp 204°C (from ethanol). PMR spectrum, δ: 3.4 (3H, s), 6.7 (d, J_{98} = 8.25 Hz, 9-H), 7.0 (d, J_{45} = 8.25 Hz, 4-H), 7.35 (t, 5-H), 7.9 (d, 8-H), and 8.3 ppm (d, J_{65} = 8.25 Hz, 6-H). Found: C 52.0; H 2.3; N 8.1%. $C_{15}H_8F_6N_2O$. Calculated: C 52.0; H 2.3; N 8.2%.

Perimidines VIII and X were similarly obtained. Compound X was obtained in 7% yield; the yellow crystals had mp 198°C (from ethanol). PMR spectrum, δ: 5.55 (d, J_{98} = 8.25 Hz, 9-H), 7.2 (8H, m), and 8.25 ppm (d, J_{65} = 8.25 Hz, 6-H). Found: C 58.8; H 2.8; N 6.9%. $C_{20}H_{10}F_6N_2O$. Calculated: C 58.7; H 2.7; N 6.8%.

General Method for the Reaction of Diamine I with Perfluorinated Acid Chlorides. A solution of 0.01 mole of the corresponding acid chloride in 5 ml of dry benzene was added dropwise in the course of 5 min to a solution of 0.01 mole of diamine I in 20 ml of dry benzene, and the mixture was refluxed with vigorous stirring for 1 h. At the end of the reaction, the benzene was evaporated, and the residual red crystals were stirred with 50 ml of water for 1 h. The yellow precipitate of a mixture of 2-perfluoro-substituted perimidine and N,N'-diacyl-1,8-naphthalenediamine was removed by filtration and separated on the basis of the different solubilities of the components in chloroform.

LITERATURE CITED

1. A. F. Pozharskii and N. M. Starshikov, Khim. Geterotsikl. Soedin., No. 10, 1418 (1978).
2. V. Paragamian, M. B. Baker, B. M. Puma, and J. Reale, J. Heterocycl. Chem., 5, 591 (1968).
3. A. F. Pozharskii and I. S. Kashparov, Khim. Geterotsikl. Soedin., No. 1, 111 (1970).
4. A. F. Pozharskii, I. V. Borovlev, and I. S. Kashparov, Khim. Geterotsikl. Soedin., No. 4, 543 (1975).
5. A. F. Pozharskii, I. S. Kashparov, P. J. Halls, and V. G. Zaletov, Khim. Geterotsikl. Soedin., No. 4, 543 (1971).
6. E. Cavalieri and R. Roth, J. Org. Chem., 41, 2679 (1976).
7. E. S. Lone, J. Chem. Soc., No. 2, 534 (1955).
8. Y. Kobayashi, J. Kudamaki, S. Taguchi, and Y. Hansawa, Tetrahedron Lett., No. 45, 3901 (1970).