Reactions of aromatic and heteroaromatic β-amino-β-polyfluoroalkylvinyl ketones with ethylenediamine. A new synthesis of *N,N'*-unsubstituted imidazolidines

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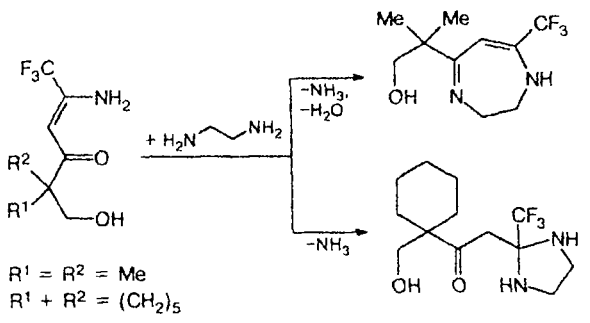
The reactions of aromatic and heteroaromatic β-amino-β-polyfluoroalkylvinyl ketones with ethylenediamine results in the formation of 2,3-dihydro-1*H*-1,4-diazepines, *N,N'*-unsubstituted imidazolidines, or *N,N'*-ethylenebis(aminovinyl ketones). The reaction route depends on the reaction conditions, the nature of the substituent at the carbonyl group, and the number of fluorine atoms in the polyfluoroalkyl radical.

Key words: aromatic β-amino-β-polyfluoroalkylvinyl ketones, ethylenediamine; 2,3-dihydro-1*H*-1,4-diazepines, *N,N'*-unsubstituted imidazolidines, *N,N'*-ethylenebis(aminovinyl ketones).

Transamination at a double bond with participation of primary and secondary amines has been described both for nonfluorinated β-aminovinyl ketones[1] and for their fluorinated analogs.[2,3] It is also known[4] that the reaction of ethylenediamine (EDA) with β-amino-β-polyfluoroalkylvinyl ketones occurring on refluxing in ethanol or benzene involves simultaneously two electrophilic centers and yields 2,3-dihydro-1*H*-1,4-diazepines. Recently,[5] when attempting to synthesize dihydrodiazepines containing a trifluoromethyl and a hydroxyalkyl group as substituents, we found that 5-amino-6,6,6-trifluoro-1-hydroxy-2,2-dimethylhex-2-en-3-one and 5-amino-6,6,6-trifluoro-1-hydroxy-2,2-pentamethylenehex-2-en-3-one react with EDA at room temperature without a solvent according to different routes. The reaction with the former aminoenone gave the expected dihydrodiazepine, but the reaction with the latter compound followed a different pathway leading to imidazolidine.



$R^1 = R^2 = Me$
$R^1 + R^2 = (CH_2)_5$

In the latter case, the process involves double nucleophilic attack on the β-carbon atom with elimination of an ammonia molecule, whereas the carbonyl group is retained, apparently, due to steric factors. Since this transformation of aminovinyl ketones has not been observed previously, we studied the reactions of a large number of aliphatic β-amino-β-trifluoromethylvinyl ketones with EDA and demonstrated[6] that thermodynamically more stable dihydrodiazepines should be expected first of all as the reaction products. However, under the conditions of kinetic control (in EDA at room temperature) and in the presence of steric hindrance at the carbonyl group, a reaction route resulting in the imidazolidine ring closure becomes more favorable.

Unlike *N,N'*-diaryl- and *N,N'*-dialkylimidazolidines, which are readily formed from the corresponding 1,2-diaryl(dialkyl)aminoethanes and aldehydes,[7,8] or 2-imidazolidone, which was prepared from methyl trichloroacetate and EDA,[9] *N,N'*-unsubstituted imidazolidines are relatively unstable organic compounds. In the series of nonfluorinated imidazolidines, only one compound, 1,4-diazaspiro[4.5]decane, resulting from interaction of cyclohexanone with EDA and rapidly decomposing in the presence of water, an acid, or a base, has been reported.[10] The formation of imidazolidines as intermediates has been postulated in the reactions of EDA with ethyl 4-oxocarboxylates[11] and *o*-aroylbenzoic acids,[12] which give 5-alkyl-1,4-diazabicyclo[3.3.0]octan-8-one and 9*b*-aryl-1,2,3,9*b*-tetrahydro-5*H*-imidazo-[2,1-*a*]isoindol-5-ones, respectively. Fluorinated *N,N'*-unsubstituted imidazolidines were first obtained, along with tetrahydro-1,4-diazepin-5-ones, by the reaction of EDA, 1,2-diaminopropane, and 2,3-diaminobutane with esters of 4,4,4-trifluoro-3-oxobutanoic and 4,4,5,5,5-pentafluoro-3-oxopentanoic acids.[10,13] Aldehydes of the general formula R^FCHO ($R^F = CF_3$, C_2F_5,

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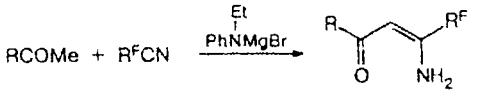
C_3F_7) react with EDA to give 2-perfluoroalkylimidazolidines, which exhibit biological activity,[14] while hexafluoroacetone is converted into 2,2-bis(trifluoromethyl)imidazolidine.[15] The reaction of trifluoromethylacetylene with EDA at −70 °C results in the synthesis of 2-(2,2,2-trifluoroethyl)imidazolidine, which is readily hydrolyzed in air.[16]

Published data[13–16] as well as results that we obtained previously[6] indicate that a polyfluoroalkyl substituent in position 2 of *N,N'*-unsubstituted imidazolidine stabilizes this heterocyclic system; this type of influence has also been observed for fluorine-containing aminals and aminoketals.[17]

Taking into account all the foregoing and also the lower reactivity of the carbonyl group attached to an aromatic substituent, one may expect that the reaction of EDA with aromatic β-amino-β-polyfluoroalkylvinyl ketone would also yield 2-aroylmethyl-2-polyfluoroalkylimidazolidines. In this work, we studied this reaction in order to find out whether it can be used for the synthesis of fluorinated *N,N'*-unsubstituted imidazolidines (for preliminary communication, see Ref. 18).

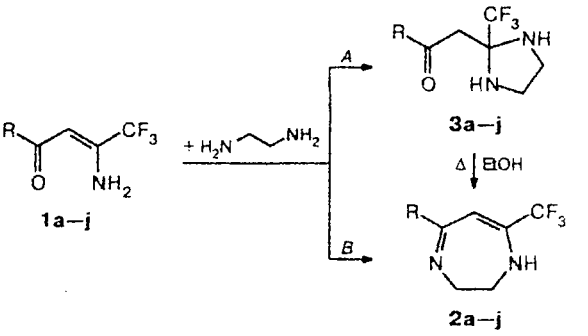
A number of aminoenones (**1a—z**) having *Z*-configuration at the double bond[20] were synthesized by condensation of trifluoro- and difluoroacetonitriles and 2,2,3,3-tetrafluoropropionitrile with the corresponding methyl ketones in the presence of *N*-ethylanilinomagnesium bromide[19]; these compounds were made to react with a threefold excess of EDA either at room temperature without a solvent (procedure *A*) or on refluxing in ethanol for 3 h (procedure *B*).



1a—z

1	R	R^F	1	R	R^F
a	Ph	CF_3	**n**	2-HO-4-$MeOC_6H_3$	CF_3
b	4-MeC_6H_4	CF_3	**o**	2-HO-5-ClC_6H_3	CF_3
c	4-$MeOC_6H_4$	CF_3	**p**	1-HO-2-$C_{10}H_6$	CF_3
d	2-$MeOC_6H_4$	CF_3	**q**	4-HOC_6H_4	CF_3
e	4-ClC_6H_4	CF_3	**r**	4-C_5H_4N	CF_3
f	4-BrC_6H_4	CF_3	**s**	4-C_5H_4N	$(CF_2)_2H$
g	3-$O_2NC_6H_4$	CF_3	**t**	Ph	$(CF_2)_2H$
h	2-C_4H_3S	CF_3	**u**	Ph	CF_2H
i	2-C_4H_3O	CF_3	**v**	2-C_4H_3S	$(CF_2)_2H$
j	1-$C_{10}H_7$	CF_3	**w**	2-C_4H_3S	CF_2H
k	2-HOC_6H_4	CF_3	**x**	2-HOC_6H_4	$(CF_2)_2H$
l	2-HO-5-MeC_6H_3	CF_3	**y**	2-HOC_6H_4	CF_2H
m	2-HO-5-$MeOC_6H_3$	CF_3	**z**	2-HO-5-$MeOC_6H_3$	CF_2H

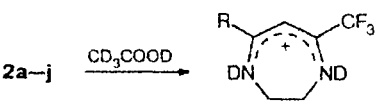
We found that the course of the reaction of aminoenones **1** with EDA depends on the reaction conditions, the nature of the substituent at the carbonyl group, and the number of fluorine atoms in the polyfluoroalkyl radical. As noted in a previous study,[4] on refluxing in ethanol, aminoenones **1**, with few exceptions, are converted into dihydrodiazepines (**2**); however, keeping trifluoromethylated aminoenones **1a—j** at ~20 °C for 1—3 h afforded imidazolidines **3a—j** in 65—95% yields; on refluxing in ethanol for 3 h, these products were converted into thermodynamically more stable dihydrodiazepines **2a—j** with liberation of water.



1a—j **3a—j** **2a—j**

It should be noted that aminoenone **1h** reacts with EDA only under the conditions of procedure *A* to give imidazolidine **3h**, which can be converted into diazepine **2h** when refluxed in ethanol for at least 6 h.

The ^1H NMR spectrum of diazepine **2a** exhibits two narrow (~6 Hz) multiplets for nonequivalent CH_2 groups of the dihydrodiazepine ring, centered at δ 3.46 and 3.99, a singlet for the vinyl proton (δ 5.28), and a substantially broadened signal at δ 4.7—5.7 for the NH-group proton. The aromatic protons are exhibited as a 5H singlet at δ 7.44, typical of a nonconjugated phenyl group.[21] When deuterioacetic acid is added to a solution of compound **2a** in $CDCl_3$, the multiplets for the methylene groups coalesce to give a singlet at δ 3.93, the singlet for the vinyl proton shifts downfield by 0.35 ppm, and the phenyl group is manifested as a multiplet at δ 7.4—7. These pronounced changes in the ^1H NMR spectrum of diazepine **2a** are due to its high basicity and to the fact that the addition of CD_3COOD affords a symmetrically delocalized monocation (*cf.* Ref. 22); consequently, the CH_2 groups become equivalent and the signal of the vinyl proton shifts downfield.



A similar situation was observed for all the diazepines, whose aromatic rings do not contain an OH group (Table 1). It should be emphasized that the ^1H NMR spectra of these compounds do not contain signals for the CH_2 group of the diimine form and that the signal of the vinyl proton is shifted downfield in the presence of CD_3COOD, while its intensity remains constant. This is at variance with the previous publication,[4] in which

analysis of the ^{1}H NMR spectrum of 7-trifluoromethyl-5-methyl-2,3-dihydro-1*H*-1,4-diazepine recorded in $CDCl_3$ led the authors to the conclusion that fluorinated dihydrodiazepines exist in three tautomeric forms. The

Table 1. ^{1}H NMR and IR spectra of 2,3-dihydro-1*H*-1,4-diazepines **2a—v,x—z**

Compound	Solvent[a]	^{1}H NMR (δ, *J*/Hz)				IR spectrum, ν/cm^{-1}
		CH_2CH_2	=CH	NH	R, R^F	
2a	A	3.46 (m), 3.99 (m)	5.28 (s)	5.2 (br.s)	7.44 (s, 5 H, Ph)	3210, 1615, 1580, 1530, 1490
	B	3.93 (s)	5.63 (s)		7.4—7.8 (m, 5 H, Ph)	
2b	A	3.50 (m), 4.05 (m)	5.29 (s)	[b]	2.39 (s, 3 H, Me); 7.30 (AB spectrum, Δδ = 0.18, 4 H, C_6H_4, *J* = 8.4)	3200, 1615, 1575, 1530, 1510
	B	3.94 (s)	5.63 (s)		2.44 (s, 3 H, Me); 7.46 (AB spectrum, Δδ = 0.28, 4 H, C_6H_4, *J* = 8.4)	
2c	A	3.50 (m), 4.05 (m)	5.28 (s)	5.2 (br.s)	3.85 (s, 3 H, MeO); 7.19 (AB spectrum, Δδ = 0.53, 4 H, C_6H_4, *J* = 8.9)	3200, 1615, 1575, 1520, 1510
	B	3.92 (s)	5.62 (s)		3.89 (s, 3 H, MeO); 7.35 (AB spectrum, Δδ = 0.68, 4 H, C_6H_4, *J* = 8.9)	
2d	A	3.50 (m), 4.10 (m)	5.14 (s)	5.7 (br.s)	3.84 (s, 3 H, MeO); 6.9—7.5 (m, 4 H, C_6H_4)	3220, 1610, 1580, 1530, 1490
	B	3.96 (s)	5.57 (s)		3.88 (s, 3 H, MeO); 7.0—7.6 (m, 4 H, C_6H_4)	
2e	A	3.52 (m), 4.06 (m)	5.26 (s)	5.2 (br.s)	7.42 (s, 4 H, C_6H_4)	3200, 1610, 1595, 1575, 1535, 1490
	B	3.95 (s)	5.57 (s)		7.58 (AB spectrum, Δδ = 0.17, 4 H, C_6H_4, *J* = 8.9)	
2f	A	3.51 (m), 4.06 (m)	5.26 (s)	5.2 (br.s)	7.46 (AB spectrum, Δδ = 0.15, 4 H, C_6H_4, *J* = 8.9)	3200, 1615, 1590, 1570, 1535, 1485
	B	3.93 (s)	5.54 (s)		7.62 (AB spectrum, Δδ = 0.05, 4 H, C_6H_4, *J* = 9.0)	
2g	C	3.40 (m), 3.96 (m)	5.09 (s)	[c]	7.5—8.3 (m, 5 H, C_6H_4, NH)	3195, 1620, 1580, 1530
	D	3.50 (s), 3.88 (s)	5.16 (s)		7.5—8.3 (m, 4 H, C_6H_4)	
2h	A	3.55 (m), 4.00 (m)	5.52 (s)	[b]	7.06 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.7); 7.28—7.41 (m, 2 H, H(3), H(5))	3200, 1610, 1570, 1530
	B	3.91 (s)	5.71 (s)		7.20 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.9); 7.71 (dd, 1 H, H(5), $J_{H(3),H(5)}$ = 1.0); 7.90 (dd, 1 H, H(3))	
2i	A	3.54 (m), 4.07 (m)	5.54 (s)	5.7 (br.s)	6.49 (dd, 1 H, H(4), $J_{H(4),H(3)}$ = 3.5, $J_{H(4),H(5)}$ = 1.8); 6.75 (dd, 1 H, H(3), $J_{H(3),H(5)}$ = 0.7); 7.47 (dd, 1 H, H(5))	3210, 1615, 1600, 1560, 1530
	B	3.93 (s)	5.84 (s)		6.65 (dd, 1 H, H(4), $J_{H(4),H(3)}$ = 3.7, $J_{H(4),H(5)}$ = 1.6); 7.44 (dd, 1 H, H(3), $J_{H(3),H(5)}$ = 0.6); 7.72 (dd, 1 H, H(5))	
2j	A	3.61 (m), 4.25 (m)	5.24 (s)	5.2 (br.s)	7.4—8.2 (m, 7 H, $C_{10}H_7$)	3215, 1620, 1590, 1570, 1535, 1510
	B	4.10 (s)	5.59 (s)		7.5—8.1 (m, 7 H, $C_{10}H_7$)	
2k	A	3.62 (m), 4.08 (m)	5.99 (s)	5.5 (br.s)[d]	6.75 (td, 1 H, H(5), ^3J = 8.0, ^4J = 1.6); 6.90 (dd, 1 H, H(3)); 7.29 (td, 1 H, H(4)); 7.58 (dd, 1 H, H(6))	3220, 1635, 1545
	B	3.84 (m), 3.96 (m)	5.74 (s)		6.8—7.6 (m, 4 H, C_6H_4)	
2l	A	3.60 (m), 4.09 (m)	5.97 (s)	5.2 (br.s), 15.7 (br.s, OH)	2.30 (s, 3 H, Me); 6.83 (d, 1 H, H(3), ^3J = 8.5); 7.10 (dd, 1 H, H(4), ^4J = 1.9); 7.33 (d, 1 H, H(6))	3210, 1635, 1530
	B	3.85 (br.s), 3.98 (br.s)	5.71 (s)		2.29 (s, 3 H, Me); 6.97 (d, 1 H, H(3), ^3J = 8.5); 7.20 (d, 1 H, H(4)); 7.25 (s, 1 H, H(6))	
2m	A	3.65 (m), 4.11 (m)	5.91 (s)	5.3 (br.s), 15.1 (br.s, OH)	3.79 (s, 3 H, MeO); 6.90—6.93 (m, 2 H, H(3), H(4)); 7.10 (br.s, 1 H, H(6))	3210, 1630, 1535
	B	3.85 (m), 4.00 (m)	5.67 (s)		3.77 (s, 3 H, MeO); 6.98—7.02 (m, 3 H, C_6H_3)	

(*to be continued*)

Table 1. (*continued*)

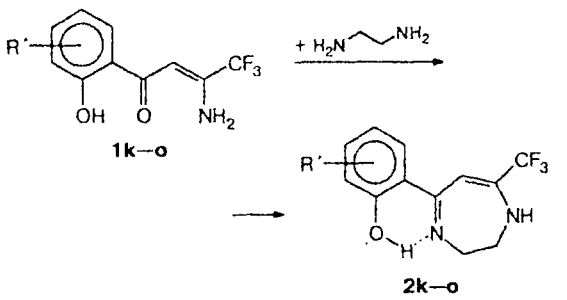
Compound	Solvent[a]	^{1}H NMR (δ, *J*/Hz)				IR spectrum, ν/cm^{-1}
		CH_2CH_2	=CH	NH	R, R^F	
2n	A	3.65 (m), 3.99 (m)	5.94 (s)	5.4 (br.s)[d]	3.80 (s, 3 H, MeO); 6.18—6.36 (m, 2 H, H(3), H(5)); 7.43 (d, 1 H, H(6), ^3J = 8.9)	3220, 1640, 1610, 1530
	B	3.76 (m), 3.98 (m)	5.77 (s)		3.81 (s, 3 H, MeO); 6.30—6.44 (m, 2 H, H(3), H(5)); 7.44 (d, 1 H, H(6), ^3J = 9.0)	
2o	A	3.64 (m), 4.10 (m)	5.88 (s)	5.2 (br.s)[d]	6.86 (d, 1 H, H(3), ^3J = 8.9); 7.22 (dd, 1 H, H(4), ^4J = 2.5); 7.52 (d, 1 H, H(6))	3210, 1630, 1510
	B	3.80 (m), 4.03 (m)	5.75 (s)		6.94 (d, 1 H, H(3), ^3J = 8.9); 7.28 (dd, 1 H, H(4), ^4J = 2.5); 7.45 (d, 1 H, H(6))	
2p	A	3.73 (m), 3.94 (m)	6.12 (d, *J* = 1.6)	5.5 (br.s) 16.5 (br.s)	6.84 (d, 1 H, H(4), ^3J = 9.2); 7.3—7.7 (m, 4 H, H(3), H(5)—H(7)); 8.44—8.56 (m, 1 H, H(8))	3220, 1635, 1610, 1565, 1530
	B	3.74 (m), 3.99 (m)	6.07 (s)		6.89 (d, 1 H, H(4), ^3J = 9.2); 7.3—7.7 (m, 4 H, H(3), H(5)—H(7)); 8.35—8.47 (m, 1 H, H(8))	
2q	C	3.31 (m), 3.89 (m)	4.99 (s)	7.8 (br.s)[d]	7.09 (AB spectrum, Δδ = 0.56, 4 H, C_6H_4, *J* = 8.6)	3320, 1620, 1595, 1570, 1535, 1510
	D	3.46 (m), 3.84 (m)	5.18 (s)		7.14 (AB spectrum, Δδ = 0.60, 4 H, C_6H_4, *J* = 8.6)	
2r	A	3.57 (m), 4.11 (m)	5.34 (s)	5.5 (br.s)	7.42 (dd, 2 H, H(3), H(5), ^3J = 4.5, ^4J = 1.6); 8.67 (dd, 2 H, H(2), H(6))	3360, 3210, 1680, 1630, 1590, 1570, 1540
	B	3.72 (m), 4.00 (m)	5.41 (s)		7.55 (dd, 2 H, H(3), H(5), ^3J = 4.5, ^4J = 1.6); 8.73 (dd, 2 H, H(2), H(6))	
2s	A	3.50 (m), 4.08 (m)	5.41 (s)	5.7 (br.s)	6.27 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.6, $^3J_{H,F}$ = 5.5); 7.42 (dd, 2 H, H(3), H(5), ^3J = 4.5, ^4J = 1.6); 8.62 (dd, 2 H, H(2), H(6))	3360, 3210, 1685, 1620, 1590, 1565, 1530
	B	3.93 (s)	5.49 (s)		6.21 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 52.9, $^3J_{H,F}$ = 3.6); 7.65 (dd, 2 H, H(3), H(5), ^3J = 4.5, ^4J = 1.6); 8.79 (dd, 2 H, H(2), H(6))	
2t	A	3.48 (m), 4.05 (m)	5.39 (s)	[b]	6.27 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.5, $^3J_{H,F}$ = 5.6); 7.3—7.6 (m, 5 H, Ph)	3215, 1605, 1575, 1530, 1490
	B	3.92 (s)	5.56 (s)		6.19 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.5, $^3J_{H,F}$ = 4.0); 7.4—7.8 (m, 5 H, Ph)	
2u	A	3.49 (m), 3.97 (m)	5.32 (d, *J* = 0.8)	4.9 (br.s)	6.01 (t, 1 H, CF_2H, $J_{H,F}$ = 56.0); 7.3—7.6 (m, 5 H, Ph)	3180, 1625, 1580, 1530
	B	3.87 (s)	5.53 (s)		6.56 (t, 1 H, CF_2H, $J_{H,F}$ = 54.0); 7.4—7.7 (m, 5 H, Ph)	
2v	A	3.52 (m), 4.00 (m)	5.60 (s)	[b]	6.25 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.6, $^3J_{H,F}$ = 5.5); 7.05 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 4.9, $J_{H(4),H(3)}$ = 3.9); 7.28—7.41 (m, 2 H, H(3), H(5))	3200, 1605, 1570, 1525
	B	3.91 (s)	5.66 (s)		6.17 (tt, 1 H, $^2J_{H,F}$ = 52.9, $^3J_{H,F}$ = 3.6); 7.20 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.1, $J_{H(4),H(3)}$ = 3.9); 7.71 (dd, 1 H, H(5), $J_{H(5),H(3)}$ = 1.2); 7.88 (dd, 1 H, H(3))	
2x	A	3.65 (m), 4.08 (m)	5.82 (s)	5.2 (br.s)[d]	5.92 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.6, $^3J_{H,F}$ = 3.3); 6.6—7.6 (m, 4 H, C_6H_4)	3190, 1630, 1610, 1530
	B	3.82 (m), 4.00 (m)	5.66 (s)		6.06 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.4, $^3J_{H,F}$ = 3.3); 6.7—7.5 (m, 4 H, C_6H_4)	
2y	A	3.62 (m), 4.05 (m)	5.67 (s)	5.5 (br.s)[d]	6.19 (t, 1 H, CF_2H, $^2J_{H,F}$ = 55.1); 6.70 (td, 1 H, H(5), ^3J = 8.0, ^4J = 1.5); 6.90 (dd, 1 H, H(3)); 7.27 (td, 1 H, H(4)); 7.57 (dd, 1 H, H(6))	3210, 1625, 1585, 1540
	B	3.81 (m), 3.87 (m)	5.54 (s)		6.40 (t, 1 H, CF_2H, $^2J_{H,F}$ = 54.4); 6.7—7.5 (m, 4 H, C_6H_4)	
2z	A	3.60 (m), 4.07 (m)	5.58 (s)	[b,d]	3.78 (s, 3 H, MeO); 6.17 (t, 1 H, CF_2H, $^2J_{H,F}$ = 55.1); 6.88—7.10 (m, 3 H, C_6H_3)	3240, 1620, 1540
	B	3.8—3.9 (m)	5.50 (s)		6.42 (t, 1 H, CF_2H, $^2J_{H,F}$ = 54.3); 6.9—7.0 (m, 3 H, C_6H_3)	

[a] A is $CDCl_3$, B is $CDCl_3$ in the presence of CD_3COOD, C is DMSO-d_6, and D is DMSO-d_6 in the presence of CD_3COOD.
[b] NH is not manifested.
[c] NH is masked by aromatic protons.
[d] OH is not manifested.

authors cited claimed[4] that in the presence of deuteriomethanol, the low-intensity signal of the CH_2 group in the diimine form disappears and the intensity of the singlet for the vinyl proton decreases. However, when we repeatedly recorded the ^1H NMR spectrum of this diazepine, we did not observe any of these changes after the addition of either CD_3COOD or CD_3OD. The absence of the diimine form has also been noted for 5,7-bis(trifluoromethyl)- and 5,7-dimethyl-2,3-dihydro-1*H*-1,4-diazepines[23,24]; in the latter case, the CH_3 and CH_2 groups are exhibited as singlets at δ 1.88 and 3.42, and the signal for the vinyl proton (δ 4.40) disappears upon the addition of deuteriosulfuric acid, indicating that in this compound, unlike fluorinated diazepines, fast H/D exchange occurs.

The IR spectra of diazepines **2a—j** recorded in Vaseline oil contain the absorption bands ν(NH) at 3195—3220 cm^{-1}, ν(C=N) at 1610—1620 cm^{-1}, ν(C=C) at 1560—1580 cm^{-1}, and a band at 1485—1535 cm^{-1} for aromatic ring vibrations (see Table 1).

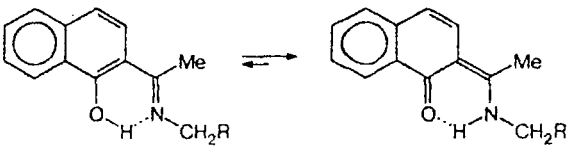
Due to the presence of the hydroxy group in the *ortho*-position of the benzene ring, aminoenones **1k—o** form only diazepines **2k—o**, irrespective of the reaction conditions.



In the ^1H NMR spectrum of diazepine **2k**, the singlet of the vinyl proton is exhibited at δ 5.99, *i.e.*, this signal shifts downfield by 0.71 ppm from that in the spectrum of **2a**. Apparently, the intramolecular hydrogen bond (IMHB) between the hydrogen atom of the OH group and the imine nitrogen atom of the diazepine ring stabilizes the planar conformation of the molecule and the vinyl proton falls in the deshielding region of the conjugated aromatic ring. For the same reason, diazepines **2k—o** are much more stable than the corresponding imidazolidines; therefore, the latter cannot be obtained, at least, by procedure *A*.

The formation of IMHB in diazepines **2k—o** not only increases their stability but also decreases the basicity of the diazepine ring, which manifests itself in the presence of CD_3COOD. The ^1H NMR spectrum of diazepine **2k** has two narrow multiplets for the methylene groups centered at δ 3.62 and 4.08, which do not become fully equivalent when CD_3COOD is added but account for two close multiplets at δ 3.84 and 3.96. In this case, the symmetrically delocalized monocation is not formed, and the signal of the vinyl proton shifts upfield by 0.25 ppm, which may be due to the deviation of the cation from the planar structure. The presence of a second substituent (Me, MeO, Cl), apart from *o*-OH, in the aromatic ring does not lead to any significant changes in the ^1H NMR spectra of diazepines **2l—o** (see Table 1). Aminoenones **1p—s**, prepared from 2-acetyl-1-naphthol, 4-hydroxyacetophenone, and 4-acetylpyridine and giving only diazepines **2p—s** in the reaction with EDA, behave similarly to compounds **1k—o**.

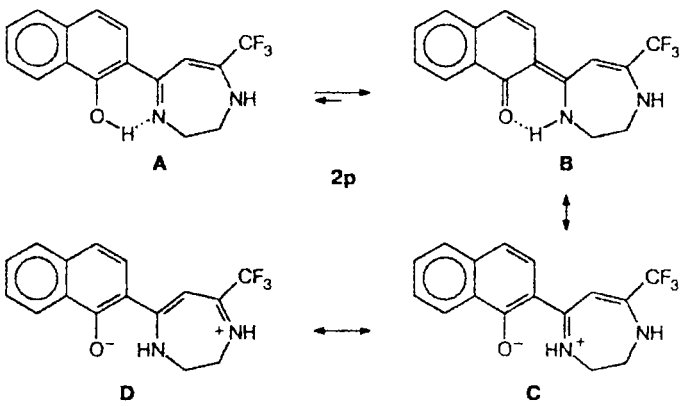
It should be noted that, unlike compounds **2a—j**, diazepines **2k—o**, which have an *ortho*-hydroxy group in the aryl substituent, are high-melting yellow, orange, or red-orange crystals. The coloration of these compounds is apparently due to the hydrogen exchange between the oxygen and nitrogen atoms, resulting in the formation of a chromophore *ortho*-quinone structure. This process is especially significant for compound **2p**, containing a 1-hydroxy-2-naphthyl substituent, because it is known[25] that Schiff's bases derived from 2-hydroxyacetophenone exist in the imine form and those derived from 2-acetyl-1-naphthol exist as enamines



R = H, Ph

In our opinion, as in the case of Schiff's bases of 2-acetyl-1-naphthol, the equilibrium between two tautomeric forms **A** and **B** in compound **2p** (red crystals) is shifted toward tautomer **B**, whose stabilization upon the formation of the keto enamine and keto dienamine systems makes up for the loss of the delocalization energy of one aromatic ring in naphthalene. The reasons for the greater capacity for stabilization in keto enamines compared with iminoenols have been reported previously.[26]

In tautomer **B**, both nitrogen atoms, having identical amine natures, are subjected to the electron-withdrawing influence of the carbonyl oxygen atom; this should decrease the basicity of the diazepine ring (the contributing structures **C**, **D**). In fact, the multiplets of the methylene groups in the ^1H NMR spectrum of compound **2p** are located closer (δ 3.73 and 3.94) than those in the spectrum of diazepine **2k**; the positions and the appearance of these signals hardly change upon the addition of CD_3COOD (δ 3.74 and 3.99), which is a consequence of the simple exchange of the "acidic" hydrogen atoms with deuterium without the formation of a diazepine cation. The signal for the vinyl proton of the diazepine ring splits at the NH-group proton not participating in the formation of IMHB into a doublet with ^4J = 1.6 Hz at δ 6.12, whereas in the presence of CD_3COOD, it occurs as a singlet at δ 6.07. The NH-



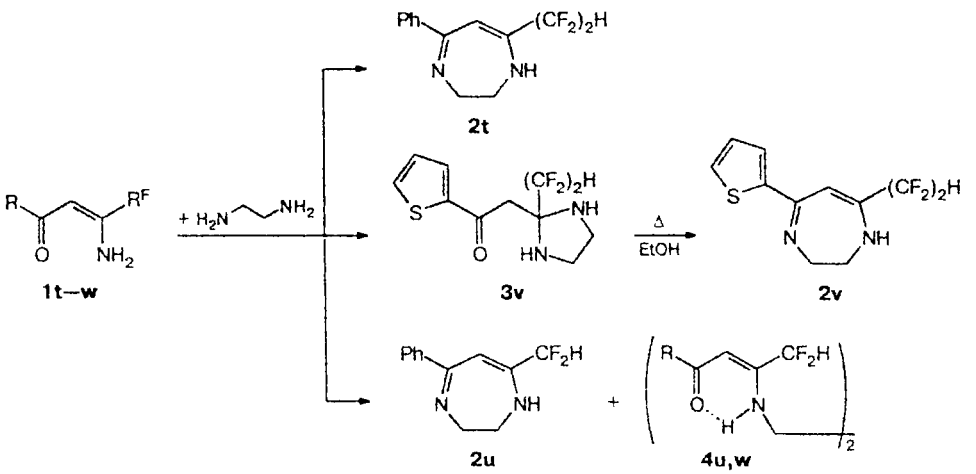
group protons (the protons involved in IMHB) are responsible for broadened singlets at δ 5.5 and 16.5, which disappear upon deuterium exchange. Unlike the initial aminoenone **1p**,[27] in which the doublet for H(4) in the naphthalene ring occurs at δ 7.22, in the spectrum of **2p**, the signal for this proton shifts upfield (a doublet at δ 6.84, J = 9.2 Hz); this can serve as additional evidence for the decrease in the degree of aromaticity of the substituted naphthalene ring.

The influence of the polyfluoroalkyl group on the course of the reaction of aminoenones **1** with EDA was studied for compounds with phenyl, 2-thienyl, and 2-hydroxyphenyl substituents at the carbonyl group; the reactions were conducted by procedure *A*. As noted above, under these conditions, CF_3-containing aminoenones **1a,h** are converted into imidazolidines **3a,h** in almost quantitative yields, and aminoenone **1k** gives diazepine **2k** (yield 64%). When the CF_3 group in the former compound is replaced by $(CF_2)_2H$ (compound **1t**), the reaction pathway changes, and only diazepine **2t** is formed in 74% yield; when this group is replaced by CF_2H (compound **1u**), the reaction affords a mixture of diazepine **2u** and *N*,*N*′-ethylenebis(3-amino-4,4-difluoro-1-phenylbut-2-en-1-one) (**4u**) in 2 : 1 ratio. It is obvious that the $(CF_2)_2H$ and CF_2H groups, which exhibit weaker $-I$ effects than the CF_3 group, hamper the double nucleophilic attack on the β-carbon atom, which leads to the imidazolidine ring closure.

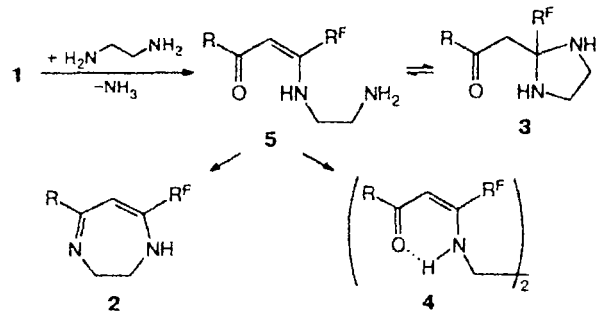
The reactivity of thiophene analogs **1v,w** differs substantially from that of aminoenones **1t,u**; these reactions give either imidazolidine **3v** (yield 92%) or ethylenebis(aminovinyl ketone) **4w** (yield 48%), indicating the lower reactivity of the carbonyl group attached to the 2-thienyl substituent. Diazepine **2v**, like **2h**, was obtained only when imidazolidine **3v** was refluxed in ethanol for 6 h.

An opposite situation was observed for aminoenones **1x—z** with 2-hydroxyphenyl substituent; they were converted only in diazepines **2x—z**, irrespective of the number of fluorine atoms in the polyfluoroalkyl radical.

Since the transamination product, ethylenebisaminoenone **4u**, is formed along with diazepine **2u**, it can be suggested that the reaction of aminoenones **1** with EDA first involves the β-carbon atom and is accompanied by elimination of an NH_3 molecule and formation of aminoenones (**5**), having a 2-aminoethyl group at the nitrogen atom; these compounds are intermediates in the synthesis of both imidazolidines **3** and ethylene-



bisaminoenones **4** and diazepines **2**. The initial formation of aminoenones **5** is confirmed indirectly by the reaction of compounds **1** with 2-aminoethanol, which stops at the transamination step and yields aminoenones with a 2-hydroxyethyl substituent at the nitrogen atom.[28]



The transformation of imidazolidines **3** into diazepines **2** on refluxing in ethanol also occurs *via* aminoenones **5**, which represent the open form of imidazolidines **3** and can be detected in the ^{1}H NMR spectra of compounds **3e,f,i** in a proportion of 5—15%; aminoenones **5** were not isolated in a pure state.

It is known[8] that in an acid medium, the ring in *N,N'*-dimethyl-2-arylimidazolidines rapidly opens to give a cationic Schiff's base, which is then hydrolyzed to an aromatic aldehyde and 1,2-dimethylaminoethane. We found that the addition of CD_3COOD to solutions of imidazolidines **3** in $CDCl_3$ induces ring opening in 30—100% of the molecules to give aminoenones **5** deuterated at the nitrogen atoms. This reaction occurs most fully (by 90—100%) in the case of imidazolidines **3e—g** having electron-withdrawing substituents (Cl, Br, NO_2) in the benzene ring.

The ^{1}H NMR spectra of compounds **3a—j,v**, in addition to the signals for the aromatic and heteroaromatic substituents, exhibit three singlets with 2 : 4 : 2 intensity ratio, which correspond to the protons at the nitrogen atoms (a broadened singlet at δ 2.5—2.9), the methylene groups of the imidazolidine ring (δ 2.99—3.11), and the exomethylene group (δ 3.22—3.45) (Table 2). When CD_3COOD is added, the broad singlet for the NH-group protons disappears and a second set of signals (A_2M_2 system) appears. The latter consists of two triplets for the ethylene unit centered at δ 3.21—3.28 and 3.71—3.81 and a signal for the vinyl proton at δ 5.99—6.39; these signals were assigned to open form **5** (see Table 2). The appearance of only one signal in the region of vinyl protons indicates stereospecific opening of the imidazolidine ring, which, judging by the close chemical shifts of the vinyl protons in compounds **1** and **5**, affords aminoenones **5** with *Z*-configuration at the double bond.

Apparently, the cleavage of the imidazolidine ring in an acid medium includes pre-equilibrium protonation of

Table 2. ^{1}H NMR and IR spectra of imidazolidines **3a—j,v** and **5a—j,v**

Compound (contents (%))	Solvent[a]	^{1}H NMR (δ, *J*/Hz)					IR spectrum, ν/cm^{-1}
		CH_2CH_2	CH_2	=CH	2 NH	R, R^F	
3a (100)	A	3.06 (s)	3.36 (s)		2.7 (br.s)	7.40—7.63 (m, 3 H, H(3)—H(5)); 7.90—8.02 (m, 2 H, H(2), H(6))	3360, 3330, 1690, 1600, 1580
3a (25), **5a** (75)	B	3.13 (s) 3.24 (t, *J* = 6.1); 3.75 (t)	3.45 (s)	6.26 (s)		7.35—7.58 (m, 3 H, H(3)—H(5)); 7.80—8.00 (m, 2 H, H(2), H(6))	
3b (100)	A	3.05 (s)	3.36 (s)		2.7 (br.s)	2.43 (s, 3 H, Me); 7.57 (AB spectrum, Δδ = 0.57, 4 H, C_6H_4, *J* = 8.4)	3360, 3320, 1680, 1605, 1570
3b (40), **5b** (60)	B	3.11 (s) 3.22 (t, *J* = 6.0); 3.73 (t)	3.41 (s)	6.24 (s)		2.40 (s, 3 H, Me); 7.50 (AB spectrum, Δδ = 0.52, 4 H, C_6H_4, *J* = 8.1)	
3c (100)	A	3.05 (s)	3.31 (s)		2.7 (br.s)	3.88 (s, 3 H, MeO); 7.45 (AB spectrum, Δδ = 0.98, 4 H, C_6H_4, *J* = 9.0)	3350, 3290, 1665, 1605, 1570, 1510
3c (40), **5c** (60)	B	3.13 (s) 3.24 (t, *J* = 6.1); 3.73 (t)	3.41 (s)	6.24 (s)		3.86 (s, 3 H, MeO); 7.40 (AB spectrum, Δδ = 0.91, 4 H, C_6H_4, *J* = 8.9)	
3d (100)	A	3.06 (s)	3.45 (s)		2.9 (br.s)	3.97 (s, 3 H, MeO); 6.9—7.7 (m, 4 H, C_6H_4)	3375, 3320, 1670, 1600, 1580

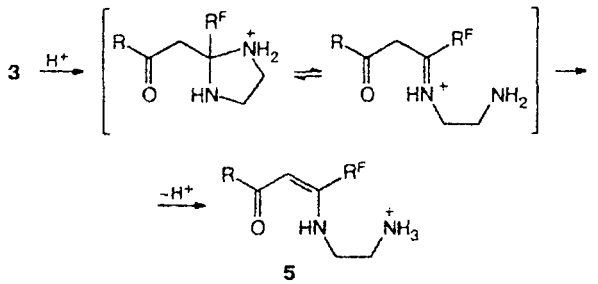
(to be continued)

Table 2. (*continued*)

Compound (contents (%))	Solvent[a]	^{1}H NMR (δ, *J*/Hz)					IR spectrum, ν/cm^{-1}
		CH_2CH_2	CH_2	=CH	2 NH	R, R^F	
3d (70), **5d** (30)	B	3.13 (s) 3.24 (t, *J* = 6.1); 3.73 (t)	3.53 (s)	6.39 (s)		3.88 (s, 3 H, MeO); 6.9—7.7 (m, 4 H, C_6H_4)	
3e (85)[b]	A	3.05 (s)	3.31 (s)		2.7 (br.s)	7.68 (AB spectrum, Δδ = 0.44, 4 H, C_6H_4, *J* = 8.9)	3350, 3320, 1690, 1595, 1570
3e (10), **5e** (90)	B	3.23 (t, *J* = 6.5); 3.75 (t)		6.20 (s)		7.61 (AB spectrum, Δδ = 0.38, 4 H, C_6H_4, *J* = 8.9)	
3f (94)[c]	A	3.04 (s)	3.29 (s)		2.5 (br.s)	7.72 (AB spectrum, Δδ = 0.19, 4 H, C_6H_4, *J* = 8.9)	3360, 3330, 1690, 1590, 1570
3f (10), **5f** (90)	B	3.24 (t, *J* = 6.3); 3.75 (t)		6.19 (s)		7.65 (AB spectrum, Δδ = 0.14, 4 H, C_6H_4, *J* = 8.9)	
3g (100)	A	3.05 (s)	3.38 (s)		2.6 (br.s)	7.71 (t, 1 H, H(5), ^3J = 8.0); 8.29 (dt, 1 H, H(6), ^4J = 1.5); 8.46 (dt, 1 H, H(4)); 8.80 (t, 1 H, H(2))	3370, 3330, 3100, 1695, 1615, 1530
5g (100)	B	3.28 (t, *J* = 6.3); 3.81 (t)		6.27 (s)		7.66 (t, 1 H, H(5), ^3J = 8.0); 8.21 (dt, 1 H, H(6), ^4J = 1.5); 8.38 (dt, 1 H, H(4)); 8.69 (t, 1 H, H(2))	
3h (100)	A	3.07 (s)	3.28 (s)		2.7 (br.s)	7.17 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.7); 7.73 (dd, 1 H, H(5), $J_{H(5),H(3)}$ = 1.2); 7.77 (dd, 1 H, H(3))	3355, 3270, 3125, 1635, 1515
3h (15), **5h** (85)	B	3.14 (s) 3.24 (t, *J* = 6.0); 3.73 (t)	3.37 (s)	6.12 (s)		7.11 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.7); 7.60 (dd, 1 H, H(5), $J_{H(5),H(3)}$ = 1.0); 7.66 (dd, 1 H, H(3))	
3i (95)[d]	A	3.05 (s)	3.22 (s)		2.7 (br.s)	6.59 (dd, 1 H, H(4), $J_{H(4),H(3)}$ = 3.6, $J_{H(4),H(5)}$ = 1.8); 7.27 (dd, 1 H, H(3), $J_{H(3),H(5)}$ = 0.7); 7.64 (dd, 1 H, H(5))	3375, 3270, 3105, 1655, 1560
3i (15), **5i** (85)	B	3.07 (s) 3.21 (t, *J* = 6.3); 3.71 (t)	3.26 (s)	6.13 (s)		6.50 (dd, 1 H, H(4), $J_{H(4),H(3)}$ = 3.5, $J_{H(4),H(5)}$ = 1.5); 7.10 (d, 1 H, H(3)); 7.54 (s, 1 H, H(5))	
3j (100)	A	3.11 (s)	3.45 (s)		2.8 (br.s)	7.4—8.1 (m, 6 H, H(2)—H(7)); 8.48—8.63 (m, 1 H, H(8))	3340, 3330, 1680, 1600, 1575, 1510
3j (50), **5j** (50)	B	3.16 (s) 3.26 (t, *J* = 6.2); 3.78 (t)	3.54 (s)	6.11 (s)		7.4—8.1 (m, 6 H, H(2)—H(7)); 8.37—8.65 (m, 1 H, H(8))	
3v (100)	A	2.99 (s)	3.24 (s)		2.8 (br.s)	6.23 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.6, $^3J_{H,F}$ = 6.3); 7.17 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.7); 7.71 (dd, 1 H, H(5), $J_{H(5),H(3)}$ = 1.0); 7.77 (dd, 1 H, H(3))	3330, 3315, 3135, 1640, 1520
3v (15), **5v** (85)	B	3.01 (s) 3.21 (t, *J* = 6.3); 3.73 (t)	3.29 (s)	5.99 (s)		6.03 (tt, 1 H, CF_2CF_2H, $^2J_{H,F}$ = 53.2, $^3J_{H,F}$ = 4.0); 7.10 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 5.0, $J_{H(4),H(3)}$ = 3.7); 7.57 (dd, 1 H, H(5), $J_{H(5),H(3)}$ = 1.0); 7.63 (dd, 1 H, H(3))	

[a] A is $CDCl_3$, B is $CDCl_3$ in the presence of CD_3COOD.
[b] Contains 15% aminoenone **5e**.
[c] Contains 6% aminoenone **5f**.
[d] Contains 5% aminoenone **5i**.

the substrate at one nitrogen atom to give a cationic Schiff's base, which undergoes irreversible tautomerization to protonated aminoenone **5**.



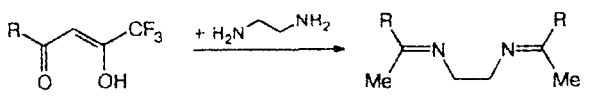
5

The IR spectra of imidazolidines **3a—j,v** contain two bands for stretching vibrations of the NH bonds at 3270—3375 cm^{-1} and ν(C=O) at 1635—1690 cm^{-1} (see Table 2).

The ^1H NMR spectra of *N,N'*-ethylenebisaminoenones **4u,w** exhibit a singlet for the vinyl proton at δ 6.01 and 5.86, a triplet for the CF_2H group at δ 6.17 and 6.15, and a broadened singlet for the NH-group proton that participates in the IMHB at δ 10.7 and 10.3, respectively. Instead of the expected singlet or doublet (resulting from splitting at the NH-group proton), the CH_2 group of the ethylene bridge is exhibited at δ 3.67 and 3.65 as a triplet, which coalesces into a singlet on the addition of CD_3COOD; this is due to the spin-spin coupling with the NH-group proton that disappears upon deuterium exchange. A similar situation has been observed for *N,N'*-ethylene(4-amino-3-pent-2-enone).[29]

Since the preparation of ethylenebisaminoenones with geminal R^F and NH groups had not been reported previously, we had to make sure that this reaction was not accompanied by isomerization of the initial aminoenones **1u,w** to aminoenones with γ-arranged CF_2H and NH groups.[30] Comparison of the ^1H NMR spectra of compounds **1u,w** and **4u,w** showed that they are fully identical in the vinyl and aromatic regions, indicating that not only the R—CO fragment but also the *Z*-configuration of the double bond has been retained in ethylenebisaminoenones **4u,w**.

In conclusion, note that on treatment with EDA under the conditions of procedure *A*, isoelectronic analogs of aminoenones **1a,h**, the enols of 1-phenyl- and 1-(2-thienyl)-4,4,4-trifluorobutane-1,3-diones (**6a,h**), are cleaved to acetophenone and 2-acetylthiophene, which then react with EDA to give *N,N'*-ethylenebisimines (**7a,h**).



6a,h **7a,h**

The product of hydrolysis of aminoenone **1k**, 2-hydroxy-2-trifluoromethyl-4-chromanone,[31] reacts with EDA in ethanol at room temperature in a similar way to give 2-hydroxyacetophenone *N,N'*-ethylenebisimine (**7k**).

Previously it has been noted[32] that the reactions of fluorinated β-diketones with amines involve mostly the carbonyl group not bound to the polyfluoroalkyl substituent and can be accompanied by cleavage of the initial β-diketone. In this connection, attention is attracted by the fact that on going from β-diketones to their aza analogs, *viz.*, aminoenones with geminal R^F and NH groups, the direction of the nucleophilic attack changes so that an N-nucleophile attacks the carbon atom bound to the R^F group, which enables regiospecific synthesis of heterocycles based on fluorine-containing β-diketones and β-aminovinyl ketones.

Thus, the study of the reactions of a large number of aromatic and heteroaromatic β-amino-β-polyfluoroalkylvinyl ketones **1** with EDA showed that this reaction can follow three different pathways, the main one of which affords thermodynamically more stable 2,3-dihydro-1*H*-1,4-diazepines **2**, but under the conditions of kinetic control and when the aromatic ring of the substrate contains no hydroxy group, the reaction can also give *N,N'*-unsubstituted 2-aroylmethyl-2-trifluoromethylimidazolidines **3**, which are cyclic aminals, or *N,N'*-ethylenebis(β-amino-β-difluoromethylvinyl ketones) **4**. The results obtained imply that these reactions occur *via* a common intermediate, namely, aminoenone **5** having a 2-aminoethyl group at the nitrogen atom.

Experimental

IR spectra were recorded on an IKS-29 instrument in Vaseline oil. ^1H NMR spectra were run in $CDCl_3$ on a Tesla BS-567A spectrometer operating at 100 MHz using tetramethylsilane as the internal standard.

The ^1H NMR and IR data for diazepines **2a—v,x—z** are presented in Table 1; those for imidazolidines **3a—j,v** are listed in Table 2. The yields, melting points, and the data of elemental analysis of the synthesized compounds are summarized in Tables 3 and 4.

2-Aroylmethyl-2-trifluoromethylimidazolidines (3a—j) and 2-(1,1,2,2-tetrafluoroethyl)-2-(2-thenoylmethyl)imidazolidine (3v). *Procedure A.* Aminoenones **1a—j,v** (1.4 mmol) were dissolved in EDA (0.25 g, 0.28 mL, 4.2 mmol), and the mixture was allowed to stand for 1—3 h at ~20 °C (when the amount of EDA was 2.1 mmol, the reaction time increased to 8—10 h). The resulting crystals were washed with water, dried, and recrystallized from hexane or CCl_4.

Under the same conditions, aminoenones **1k—t,x—z** gave the corresponding diazepines; **1u** gave a mixture of diazepine **2u** and ethylenebisaminoenone **4u**, which was not separated; **1w** was converted into ethylenebisaminoenone **4w**. The ^1H NMR spectrum of a mixture of compounds **2u** and **4u** exhibited two sets of signals belonging to diazepine **2u** and ethylenebisaminoenone **4u** in 2 : 1 ratio.

***N,N'*-Ethylenebis(3-amino-4,4-difluoro-1-phenylbut-2-en-1-one) (4u).** ^1H NMR, δ: 3.67 (t, 2 H, CH_2); 6.01 (s, 1 H, =CH); 6.17 (t, 1 H, CF_2H, $^2J_{H,F}$ = 53.2 Hz); 7.3—7.9 (m, 5 H, Ph); 10.7 (br.s, 1 H, NH).

***N,N'*-Ethylenebis(3-amino-4,4-difluoro-1-2'-thienylbut-2-en-1-one) (4w).** Yield 48%, m.p. 176—177 °C. IR, ν/cm^{-1}: 3150 (NH), 1620 (C=O), 1565 (C=C), 1530 (δ NH), 1500

Table 3. Yields, melting points, and elemental analysis data for dihydrodiazepines **2a—t,v,x—z**

Compound	Yield (%)	M.p. /°C	Molecular formula	Found / Calculated (%)		
				C	H	N
2a	85	148—149[a]	$C_{12}H_{11}F_3N_2$	59.75 60.00	4.49 4.62	11.78 11.66
2b	60	161—162	$C_{13}H_{13}F_3N_2$	61.32 61.41	5.02 5.15	10.88 11.02
2c	64	159—160	$C_{13}H_{13}F_3N_2O$	57.80 57.78	4.92 4.85	10.27 10.37
2d	75	153—154	$C_{13}H_{13}F_3N_2O$	57.69 57.78	4.97 4.85	10.28 10.37
2e	68	196—197	$C_{12}H_{10}ClF_3N_2$	52.23 52.47	3.75 3.67	10.35 10.20
2f	76	203—204	$C_{12}H_{10}BrF_3N_2$	45.34 45.16	3.15 3.16	8.88 8.78
2g	67	196—197	$C_{12}H_{10}F_3N_3O_2$	50.68 50.53	3.45 3.53	14.89 14.73
2h	70	102—103	$C_{10}H_9F_3N_2S$	48.51 48.77	3.80 3.68	11.27 11.38
2i	73	120—121	$C_{10}H_9F_3N_2O$	51.93 52.18	4.17 3.94	12.34 12.17
2j	67	208—209	$C_{16}H_{13}F_3N_2$	66.49 66.20	4.34 4.51	9.88 9.65
2k	64	198—199	$C_{12}H_{11}F_3N_2O$	56.00 56.25	4.57 4.33	10.92 10.93
2l	75	197—198	$C_{13}H_{13}F_3N_2O$	57.90 57.78	4.80 4.85	10.45 10.37
2m	62	182—183	$C_{13}H_{13}F_3N_2O_2$	54.40 54.55	4.72 4.58	9.90 9.79
2n	76	212—214	$C_{13}H_{13}F_3N_2O_2$	54.69 54.55	4.52 4.58	9.79 9.79
2o	87	243—244	$C_{12}H_{10}ClF_3N_2O$	49.59 49.59	3.39 3.47	9.70 9.64
2p	78	231—232	$C_{16}H_{13}F_3N_2O$	62.78 62.74	4.54 4.28	9.36 9.15
2q	58	256—257	$C_{12}H_{11}F_3N_2O$	56.18 56.25	4.49 4.33	11.12 10.93
2r	65	83—85	$C_{11}H_{10}F_3N_3 \cdot H_2O$	51.14 50.97	4.58 4.67	16.42 16.21
2s	77	108—109	$C_{12}H_{11}F_4N_3 \cdot 0.5H_2O$	51.22 51.07	4.29 4.29	15.00 14.89
2t	74	123—124[b]	$C_{13}H_{12}F_4N_2$	57.49 57.35	4.24 4.44	10.22 10.29
2v	54	107—108	$C_{11}H_{10}F_4N_2S$	47.46 47.48	3.49 3.62	10.03 10.07
2x	72	200—201	$C_{13}H_{12}F_4N_2O$	54.21 54.17	4.17 4.20	9.53 9.72
2y	70	178—179	$C_{12}H_{12}F_2N_2O$	60.52 60.50	5.10 5.08	11.81 11.76
2z	81	172—173	$C_{13}H_{14}F_2N_2O_2$	58.15 58.21	5.30 5.26	10.56 10.44

[a] Lit. data[4]: m.p. 147.5 °C.
[b] Lit. data[4]: m.p. 121.5 °C.

(thiophene ring). ^{1}H NMR, δ: 3.65 (t, 2 H, CH_2); 5.86 (s, 1 H, =CH); 6.15 (t, 1 H, CF_2H, $^2J_{H,F}$ = 53.4 Hz); 7.09 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 4.9 Hz, $J_{H(4),H(3)}$ = 3.7 Hz); 7.52—7.65 (m, 2 H, H(3), H(5)); 10.3 (br.s, 1 H, NH).

Table 4. Yields, melting points, and elemental analysis data for imidazolidines **3a—j,v**

Compound	Yield (%)	M.p. /°C	Molecular formula	Found / Calculated (%)		
				C	H	N
3a	94	99—100	$C_{12}H_{13}F_3N_2O$	55.75 55.81	4.94 5.07	10.94 10.85
3b	88	124—125	$C_{13}H_{15}F_3N_2O$	57.13 57.35	5.62 5.55	10.57 10.29
3c	94	112—113	$C_{13}H_{15}F_3N_2O_2$	54.28 54.17	5.40 5.25	9.88 9.72
3d	85	98—99	$C_{13}H_{15}F_3N_2O_2$	54.18 54.17	5.27 5.25	9.73 9.72
3e	85	102—103	$C_{12}H_{12}ClF_3N_2O$	49.18 49.24	4.00 4.13	9.29 9.57
3f	87	114—115	$C_{12}H_{12}BrF_3N_2O$	42.59 42.75	3.68 3.59	8.20 8.31
3g	90	121—122	$C_{12}H_{12}F_3N_3O_3$	47.53 47.53	3.88 3.99	14.00 13.86
3h	95	117—118	$C_{10}H_{11}F_3N_2OS$	45.31 45.45	4.09 4.20	10.50 10.60
3i	65	104—105	$C_{10}H_{11}F_3N_2O_2$	48.34 48.39	4.72 4.47	11.58 11.29
3j	66	87—88	$C_{16}H_{15}F_3N_2O$	62.54 62.33	4.78 4.90	9.03 9.09
3v	92	110—111	$C_{11}H_{12}F_4N_2OS$	44.72 44.59	4.19 4.08	9.28 9.45

5-Aryl(hetaryl)-7-polyfluoroalkyl-2,3-dihydro-1*H*-1,4-diazepines (2a—t,v,x—z). *Procedure B.* Aminoenones **1a—g,i—t,x—z** (1.4 mmol) and EDA (0.13 g, 0.14 mL, 2.1 mmol) were dissolved in 3 mL of ethanol and refluxed for 3 h; the solvent was evaporated, and the residue was recrystallized from alcohol or a mixture of hexane with benzene. Aminoenones **1h** and **1v** did not react with EDA under these conditions. Dihydrodiazepines **2a—g,i,j** were also obtained from the corresponding imidazolidines on refluxing in ethanol for 3 h; in the synthesis of **2h,v**, the mixture was refluxed for 6 h. After that, diazepine **2h** contained 8% of the initial imidazolidine **3h** (^{1}H NMR data).

Acetophenone *N,N'*-ethylenebisimine (7a) was prepared from β-diketone **6a** by procedure *A*. Yield 65%, m.p. 107—108 °C (lit[33]: m.p. 108—110 °C). IR, ν/cm^{-1}: 1630 (C=N); 1575, 1495 (benzene ring). ^{1}H NMR, δ: 2.29 (s, 3 H, Me); 3.92 (s, 2 H, CH_2); 7.2—7.8 (m, 5 H, Ph).

2-Acetylthiophene *N,N'*-ethylenebisimine (7h) was prepared from β-diketone **6h** by procedure *A*. Yield 78%, m.p. 138—139 °C. Found (%): C, 61.04; H, 5.77; N, 10.28. $C_{14}H_{16}N_2S_2$. Calculated (%): C, 60.83; H, 5.83; N, 10.13. IR, ν/cm^{-1}: 3070 (CH=), 1620 (C=N), 1525 (thiophene ring). ^{1}H NMR, δ: 2.26 (s, 3 H, Me); 3.86 (s, 2 H, CH_2); 6.99 (dd, 1 H, H(4), $J_{H(4),H(5)}$ = 4.7 Hz, $J_{H(4),H(3)}$ = 3.9 Hz); 7.25—7.33 (m, 2 H, H(3), H(5)).

2-Hydroxyacetophenone *N,N'*-ethylenebisimine (7k). 2-Hydroxy-2-trifluoromethyl-4-chromanone (0.21 g, 0.9 mmol) was dissolved with heating in 2 mL of ethanol, and 0.2 mL of EDA (0.18 g, 3.0 mmol) was added to the warm solution. After 0.5 h, the resulting solution was diluted with 4 mL of water and allowed to stand for 24 h at ~20 °C. The yellow crystals of imine **7k**, containing a minor impurity of orange-red crystals of diazepine **2k**, were filtered off. Recrystallization from ethanol gave 0.1 g of imine **7k**, yield 75%, m.p. 192—193 °C. Found (%): C, 73.06; H, 6.87; N, 9.40. $C_{18}H_{20}N_2O_2$. Calculated (%): C, 72.95; H, 6.80; N, 9.45. IR, ν/cm^{-1}: 1615 (C=N); 1575, 1510 (benzene ring). ^{1}H NMR, δ: 2.37 (s, 3 H, Me); 3.97 (s, 2 H, CH_2); 6.78 (td, 1 H, H(5), ^3J = 7.8 Hz, ^4J = 1.5 Hz); 6.90 (dd, 1 H, H(3)); 7.28 (td, 1 H, H(4)); 7.52 (dd, 1 H, H(6)).

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