Synthesis of 2-arylhydrazones of aliphatic fluorine-containing 1,2,3-tricarbonyl compounds and their reactions with dinucleophiles

*O. G. Kuzueva, Ya. V. Burgart, and V. I. Saloutin**

Institute of Organic Synthesis, Ural Branch of the Russian Academy of Sciences, 20 ul. S. Kovalevskoi, 620219 Ekaterinburg, Russian Federation. Fax: +7 (343 2) 74 5954. E-mail: fc@ios.ural.ru

New fluorinated 2-arylhydrazones of 1,2,3-tricarbonyl compounds were obtained by coupling fluorine-containing 3-oxo esters, 1,3-diketones, and their copper chelates with aryldiazonium chlorides. Reactions of these arylhydrazones with hydrazine hydrate, phenylhydrazine, thiosemicarbazide, and hydroxylamine gave the corresponding pyrazole and isoxazole derivatives.

Key words: azo-coupling, aliphatic fluorine-containing 1,3-dicarbonyl compounds, arylhydrazones, pyrazole, isoxazole.

Coupling of aryldiazonium salts with 1,3-dicarbonyl compounds at the reactive methylene group is a classical reaction in organic chemistry.[1] The diversity of products (including those with biological activity) obtained from 2-arylhydrazones of aliphatic 2,3-dioxo esters and 1,2,3-triketones makes it worthwhile to synthesize fluorine-containing tricarbonyl compounds and to create various heterocyclic systems based on them.

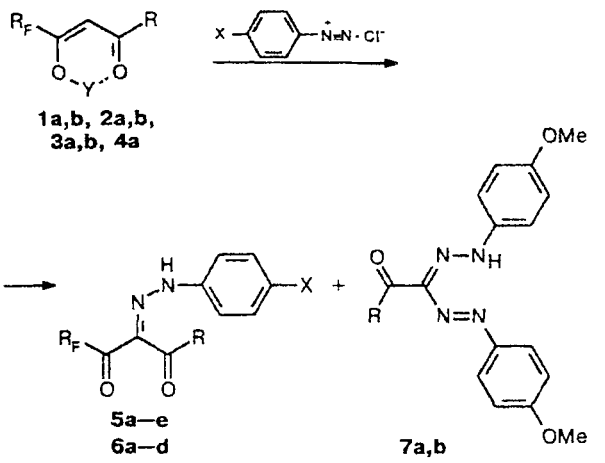
Esters of 2-phenylhydrazonotrifluoroacetoacetic[2] and -pentafluorobenzoylacetic[3] acids are the only known representatives of 2-arylhydrazones of 2,3-dioxo esters. There are no data on the involvement of these compounds in heterocyclization reactions. The series of 2-arylhydrazono derivatives of fluorinated 1,3-diketones is wider,[2,4] and substituted pyrazoles and isoxazoles have been obtained based on them.[4] However, a systematic study in this field is still lacking.

In the present work, we synthesized new 2-arylhydrazones of fluorine-containing 1,2,3-tricarbonyl compounds and studied their reactions with dinucleophiles.

We showed that fluorine-containing 3-oxo esters (**1a,b**), 1,3-diketones (**2a,b**), and copper chelates (**3a,b**, **4a**) react with aryldiazonium chlorides in a water-alcohol medium in the presence of sodium acetate to give 2-arylhydrazones of 2,3-dioxo esters (**5a—e**) and 1,2,3-triketones (**6a—d**) (Table 1, Scheme 1).

It should be noted that trifluoroacetoacetate **1a** and trifluoroacetylacetone **2a** undergo partial acid cleavage to give the corresponding formazans (**7a,b**) as side products. On the other hand, a 3-oxo ester and a 1,3-diketone with bulky substituents (perfluorobutyl in **1b** or tetrafluoroethyl in **2b**), which probably hinder the attack by a second diazonium salt molecule and thus prevent the decomposition of the hydrazone, give only arylhydrazones in the reactions studied.

Scheme 1



Y = H, R = OEt, R_F = CF_3, X = OMe (**1a**, **5a**, **7a**),
R_F = C_4F_9, X = OMe (**1b**, **5b**), Me (**5c**);
R = Me, R_F = CF_3, X = OMe (**2a**, **6a**, **7b**);
R_F = $H(CF_2)_2$, X = OMe (**2b**, **6b**), Me (**6c**), H (**6d**);
Y = $Cu/_2$, R = OMe, R_F = CF_3, X = OMe (**3a**, **5d**),
R_F = C_4F_9, X = OMe (**3b**, **5e**);
R = Me, R_F = CF_3, X = OMe (**4a**, **6a**)

The reactions under consideration are also considerably affected by the nature of the aryldiazonium component. For example, the tendency of arylhydrazones to acid cleavage in the reaction of fluorinated dicarbonyl compounds with diazotized anilines increases and their yield decreases in the series: *p*-anisidine, *p*-toluidine, aniline.

Translated from *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 4, pp. 695—700, April, 1998.

1066-5285/98/4704-0673 $20.00

Table 1. Main characteristics of compounds **5—13**

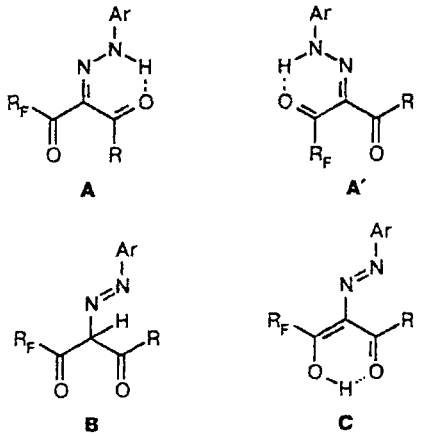
Compound	Yield (%)	M.p./°C	Found / Calculated (%) C	H	F	N	Molecular formula	IR, ν/cm^{-1}	NMR spectrum, δ, *J*/Hz ^{1}H	^{19}F
5a	73	135—136	49.05 49.06	4.06 4.12	17.97 17.91	8.83 8.80	$C_{13}H_{13}F_3N_2O_4$	3070, 1600 (NH); 1690 (COOEt); 1650 (C=O); 1580, 1520, 1510 (C=N, C=C)	1.36 (t, 3 H, $OCH_2\underline{Me}$, J = 7.1); 3.86 (s, 3 H, OMe); 4.37 (q, 2 H, $O\underline{CH_2}Me$, J = 7.1); 7.30 (m, 4 H, C_6H_4); 9.00 (br.s, 1 H, NH)	93.72 (s, CF_3)
5b	81	77—78	40.97 41.04	3.13 2.80	36.81 36.51	5.95 5.98	$C_{16}H_{13}F_9N_2O_4$	3090, 1615 (NH); 1685 (COOEt); 1660 (C=O); 1600, 1520—1500 (C=N, C=C)	1.36 (t, 3 H, $OCH_2\underline{Me}$, J = 7.0); 3.86 (s, 3 H, OMe); 4.38 (q, 2 H, $O\underline{CH_2}Me$, J = 7.0); 7.30 (m, 4 H, C_6H_4); 13.43 (br.s, 1 H, NH)	
5c	75	43—45	42.59 42.49	3.29 2.90	37.57 37.81	6.16 6.19	$C_{16}H_{13}F_9N_2O_3$	3100, 1600 (NH); 1690 (COOEt); 1660 (C=O); 1590, 1520, 1510 (C=N, C=C)	1.40 (t, 3 H, $OCH_2\underline{Me}$, J = 7.1); 2.35 (s, 3 H, Me); 4.38 (q, 2 H, $O\underline{CH_2}Me$, J = 7.1); 7.24 (m, 4 H, C_6H_4); 13.50 (br.s, 1 H, NH)	36.84 (m, 2 F, CF_2); 41.26 (m, 2 F, CF_2); 50.44 (m, 2 F, CF_2); 81.10 (m, 3 F, CF_3)
5d	72	142—144	47.31 47.38	3.69 3.64	18.62 18.73	9.23 9.21	$C_{12}H_{11}F_3N_2O_4$	3080, 1605 (NH); 1700 (COOMe); 1650 (C=O); 1590, 1520—1500 (C=N, C=C)	3.86 (s, 3 H, OMe); 3.94 (s, 3 H, OMe); 7.08 (m, 4 H, C_6H_4); 14.40 (br.s, 1 H, NH)	96.72 (s, CF_3)
5e	78	81—82	41.49 41.60	2.79 2.74	32.80 37.90	6.76 6.93	$C_{15}H_{11}F_9N_2O_4$	2730, 1615 (NH); 1685 (COOMe); 1660 (C=O); 1600, 1520—1500 (C=N, C=C)	3.83 (s, 3 H, OMe); 3.92 (s, 3 H, OMe); 7.13 (m, 4 H, C_6H_4); 13.60 (br.s, 1 H, NH)	38.72 (m, 2 F, CF_2); 51.22 (m, 2 F, CF_2); 83.78 (m, 3 F, CF_3)
6a	70	116—117	50.07 50.01	3.84 3.85	19.83 19.77	9.68 9.72	$C_{12}H_{11}F_3N_2O_3$	2710, 1615 (NH); 1685 (C=O); 1590, 1500 (C=N, C=C)	2.61 (s, 3 H, Me); 3.84 (s, 3 H, OMe); 7.20 (m, 4 H, C_6H_4); 15.40 (br.s, 1 H, NH)	91.66 (s, CF_3)
6b	85	130—131	48.53 48.76	3.83 3.78	24.09 23.73	8.51 8.75	$C_{13}H_{12}F_4N_2O_3$	2720, 1615 (NH); 1670 (C=O); 1590, 1580, 1500 (C=N, C=C)	2.56 (s, 3 H, OMe); 3.87 (s, 3 H, OMe); 6.71 (t.t, 1 H, $H(CH_2)_2$, $J_{CF_2,H}$ = 52.8, J_{CF_2,HCF_2} = 7.3); 7.30 (m, 4 H, C_6H_4); 13.30 (br.s, 1 H, NH)	26.65 (d.t, 2 F, HCF_2, J_{H,CF_2} = 52.8, J_{CF_2,CF_2} = 7.3); 44.02 (d.t, 2 F, CF_2, J_{CF_2,CF_2} = 7.3)
6c	80	90—91	51.42 51.32	3.93 3.98	24.77 24.98	9.29 9.21	$C_{13}H_{12}F_4N_2O_3$	3370, 1600 (NH); 1680 (C=O); 1580, 1510—1500 (C=N, C=C)	2.39 (s, 3 H, Me); 2.61 (s, 3 H, Me); 6.35 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 53.3, J_{CF_2,HCF_2} = 6.7); 7.30 (m, 4 H, C_6H_4); 15.25 (br.s, 1 H, NH)	25.06 (d.t, 2 F, HCF_2, J_{H,CF_2} = 53.3, J_{CF_2,CF_2} = 6.7); 44.26 (d.t, 2 F, CF_2, J_{CF_2,CF_2} = 6.7)
6d	74	125—126	49.88 49.66	3.27 3.47	25.70 26.18	9.64 9.65	$C_{12}H_{10}F_4N_2O_2$	3380, 1610 sh; (NH) 1680 (C=O); 1580, 1500 (C=N, C=C)	2.62 (s, 3 H, Me); 6.35 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 53.2, J_{CF_2,HCF_2} = 6.6); 7.44 (m, 5 H, Ph); 15.20 (br.s, 1 H, NH)	24.96 (d.t, 2 F, HCF_2, J_{H,CF_2} = 53.2, J_{CF_2,CF_2} = 6.6); 44.26 (d.t, 2 F, CF_2, J_{CF_2,CF_2} = 6.6)

to be continued

Table 1. (Continued)

Compound	Yield (%)	M.p./°C	Found / Calculated (%) C	H	F	N	Molecular formula	IR, ν/cm^{-1}	NMR spectrum, δ, *J*/Hz ^{1}H	^{19}F
7a	20	131—132, *cf.* Ref. 8	60.35 / 60.67	5.80 / 5.62		15.87 / 15.73	$C_{18}H_{20}N_4O_4$	3040, 1650 (NH); 1710, 1680 (COOEt); 1585, 1490 (C=C, C=N, N=N)	1.39 (t, 3 H, $OCH_2\underline{Me}$, J = 7.1); 3.87 (s, 6 H, 2 OMe); 4.36 (q, 2 H, $O\underline{CH_2}Me$, J = 7.1); 7.4 (m, 4 H, C_6H_4); 12.83 (br.s, 1 H, NH)	
7b	24	150—151, *cf.* Ref. 8	62.70 / 62.57	5.47 / 5.56		16.82 / 17.17	$C_{17}H_{18}N_4O_3$	2730, 1650 (NH); 1670 (C=O); 1590, 1490 (C=N, C=C, N=N)	2.61 (s, 3 H, Me); 3.85 (s, 6 H, 2 OMe); 7.23 (m, 4 H, C_6H_4); 15.97 (br.s, 1 H, NH)	
8	79	157—158	38.40 / 38.55	2.09 / 2.08	39.02 / 39.20	12.76 / 12.84	$C_{14}H_9F_9N_4O_2$	3260, 1600 (NH); 1660 (C=O); 1590, 1540, 1500 (C=N, C=C)	3.85 (s, 3 H, OMe); 7.28 (m, 4 H, C_6H_4); 9.70, 15.3 (br.s, 2 H, 2 NH)	36.52 (m, 2 F, CF_2); 38.92 (m, 2 F, CF_2); 49.66 (m, 2 F, CF_2); 80.92 (m, 3 F, CF_3)
9	80	140—141	46.29 / 46.00	2.79 / 2.81	19.73 / 19.84	14.68 / 14.63	$C_{11}H_8F_3N_3O_3$	3170, 1590 (NH); 1730, 1720 (C=O); 1550, 1530, 1500 (C=N, C=C)	3.87 (s, 3 H, OMe); 7.28 (m, 4 H, C_6H_4); 13.00 (br.s, 2 H, NH)	96.52 (s, CF_3)
10a	83	182—183	49.42 / 49.41	3.77 / 3.82	24.17 / 24.03	17.74 / 17.71	$C_{13}H_{12}F_4N_4O$	3160, 3080, 1590 (NH); 1580, 1500, 1490 (C=N, C=C)	2.64 (s, 3 H, Me); 3.88 (s, 3 H, OMe); 6.56 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 53.7, J_{CF_2,HCF_2} = 6.6); 7.44 (m, 4 H, C_6H_4); 12.20 (br.s, 1 H, NH)	24.40 (d.t, 2 F, HCF_2, J_{H,CF_2} = 53.7, J_{CF_2,CF_2} = 6.6); 44.25 (d.t, 2 F, CF_2, J_{CF_2,CF_2} = 6.6)
10b	81	180—181	50.20 / 50.36	3.33 / 3.52	26.40 / 26.55	19.43 / 19.57	$C_{12}H_{10}F_4N_4$	3140, 3080, 1570 (NH); 1500 sh, 1490 (C=N, (C=C)	2.65 (s, 3 H, Me); 6.54 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 53.6, J_{CF_2,HCF_2} = 5.5); 7.30 (m, 5 H, Ph); 12.30 (br.s, 1 H, NH)	
11	82	115—116	58.14 / 58.16	4.17 / 4.11	19.23 / 19.37	14.22 / 14.28	$C_{19}H_{16}F_4N_4O$	1590, 1570, 1490 (C=N, N=N, C=C)	2.63 (s, 3 H, Me); 3.88 (s, 3 H, OMe); 6.58 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 53.5, J_{CF_2,HCF_2} = 5.4); 7.46 (m, 9 H, C_6H_4, C_6H_5)	
12	84	125—126	42.56 / 42.75	3.91 / 3.84	19.58 / 19.31	17.54 / 17.88	$C_{14}H_{15}F_4N_5O_2S$	3420, 3300, 1600 (NH); 3150 (OH); 1570, 1515, 1500 (N=N, C=N)	2.22 (s, 3 H, Me); 3.79 (s, 3 H, OMe); 6.69 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 51.7, J_{CF_2,HCF_2} = 6.7); 7.06 (m, 4 H, C_6H_4); 7.9, 8.6, 9.7 (br.s, 4 H, NH_2, NH, OH)	
13	79	85—86	48.63 / 48.91	4.33 / 4.10	23.65 / 23.80	12.88 / 13.16	$C_{13}H_{13}F_4N_3O_2$	3350, 3120, 1600 (NH, OH); 1570 1520, 1500 (N=N, C=C)	2.09 (s, 3 H, Me); 2.31 (s, 3 H, Me); 6.04 (t.t, 1 H, $H(CF_2)_2$, $J_{CF_2,H}$ = 52.7, J_{CF_2,HCF_2} = 6.2); 7.07 (m, 4 H, C_6H_4); 9.06 (br.s, 2 H, NH, OH)	

The azo-hydrazone rearrangement[1] is a characteristic feature of azo-coupling products. Non-fluorinated tricarbonyl compounds exist as hydrazones, but the presence of fluorinated substituents is known to increase the degree of enolization of 1,3-dicarbonyl compounds.[5] In view of this, it might be assumed that products **5a—e** and **6a—d** would tend to both the azo-hydrazone (**A(A′)** ⇌ **B**) and the keto-enol (**B** ⇌ **C**) tautomerism.



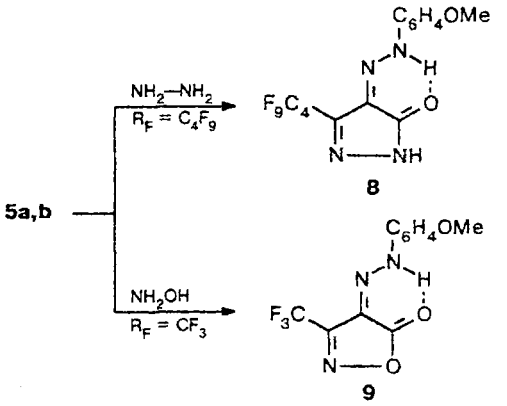
The existence of only one set of signals in the ^1H and ^{19}F NMR spectra of compounds **5a—e** and **6a—d** suggests unambiguously that one tautomeric form is present in each case. The absence of the methine proton signal in the ^1H NMR spectra of these products rules out the existence of the azoketone form **B**. The intense absorption bands at 1695—1650 cm^{-1} observed in the IR spectra of compounds **5a—e**, **6a—d** can be explained by the presence of oxo groups in these compounds, which is possible only in the case of the hydrazono-keto forms **A** or **A′**.

The somewhat decreased stretching vibration frequencies of carbonyl groups (in comparison with those reported in the literature[6]) are caused, on the one hand, by their conjugation with the C=N bond, and on the other hand, by the participation of the arylhydrazone fragment in a hydrogen bond with the amino group. This kind of interaction also follows from the presence of a broadened singlet low-field signal of the amino group proton in the ^1H NMR spectra of compounds **5a—e**, **6a—d** and by the weak absorption at 2730—2710 cm^{-1} in the IR spectra of these compounds. This hydrogen bond can involve either the carbonyl at the fluorinated group (**A′**), or the ester group in the case of 3-oxo esters, or the acyl group (**A**) in the case of 1,3-diketones. In our opinion, one cannot choose between the tautomers based on the available spectral data, although the **A′** form was preferred in an earlier study.[2]

We were the first to use copper(II) 3-oxo esterates and 1,3-diketonate **3a,b** and **4a** in azo-coupling. The use of copper chelates makes it possible to obtain 2-arylhydrazono-substituted products in high yields, bypassing the step of chelate decomposition in the synthesis of free ligands. In addition, the use of copper chelates decreases the probability of decomposition of hydrazones to give formazans.

Some of the arylhydrazones were used in the synthesis of heterocyclic compounds. For example, reactions of 2-arylhydrazones of 2,3-dioxo esters **5a,b** with hydrazine hydrate and hydroxylamine gave pyrazolinone **8** and isoxazolinone **9**, respectively (see Table 1 and Scheme 2).

Scheme 2



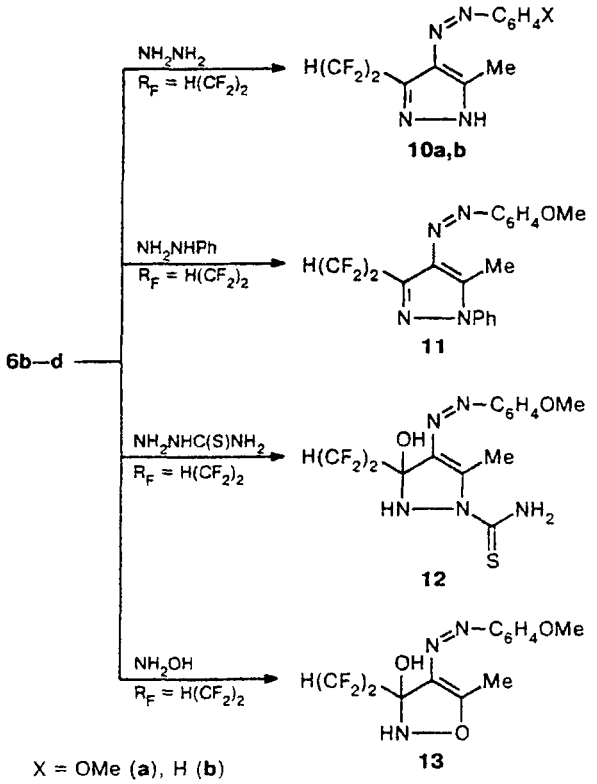
Heterocycles **8** and **9** can exist both in azo- and hydrazono-forms. Pyrazole **8** is also characterized by amido-hydroxyimine tautomerism. However, NMR spectroscopic data (see Table 1) indicate that only one of the possible tautomers is present in each case. In our opinion, the amide form is most probable for product **8**, since its IR spectrum contains an intense absorption band at 1660 cm^{-1}. The downfield shift of absorption bands of the amide (in the case of compound **8**) and ester (in the case of **9**) carbonyl groups is caused by their involvement in a hydrogen bond with the amino group, which can exist only in the hydrazo-form.

We showed that 2-arylhydrazones of 1,2,3-triketones **6b—d** react with hydrazine hydrate, phenylhydrazine, thiosemicarbazide, and hydroxylamine to give pyrazole derivatives (**10a,b**, **11**, **12**) and isoxazole (**13**) (see Table 1 and Scheme 3).

It seems impossible to decide, based on the available spectroscopic data, in which (azo or hydrazono) form pyrazoles **10a,b** are present, whereas compounds **11—13** can exist only in the azo-form. It may be assumed that, unlike heterocycles **8** and **9**, whose hydrazono-form is possibly stabilized by a hydrogen bond, the azo-form is preferable for compounds **10a,b**.

Products **12** and **13** are stable against dehydration and do not eliminate water upon prolonged heating *in vacuo* or upon refluxing in toluene. The trend to the

Scheme 3



formation of stable hydrated heterocycles was also observed for other 2-substituted fluorine-containing 1,3-dicarbonyl compounds.[7]

Thus, we have demonstrated that the 2-arylhydrazones of 2,3-dioxo esters and 1,2,3-triketones obtained have a reactivity similar to that of 2-substituted fluorine-containing 1,3-dicarbonyl compounds and can serve as promising synthons for the construction of heterocyclic systems.

Experimental

IR spectra were recorded on a Specord 75 IR spectrophotometer at 400—4000 cm^{-1} (suspensions in Vaseline oil). ^1H NMR spectra were measured on a Tesla BS-567 A spectrometer (100 MHz) relative to $SiMe_4$. ^{19}F NMR spectra were obtained on a Tesla BS-587 A spectrometer (75 MHz) relative to C_6F_6.

Ethyl 4,4,4-trifluoro-2-(4-methoxyphenyl)hydrazono-3-oxobutyrate (5a). A solution of a diazonium salt prepared from *p*-anisidine (0.14 g, 1.1 mmol), concentrated HCl (2 mL), and $NaNO_2$ (0.08 g, 1.1 mmol) in water (10 mL) was added at 10 °C in portions with stirring to oxo ester **1a** (0.18 g, 1 mmol) in MeOH (10 mL). Concentrated aqueous AcONa was then added slowly until the solution became turbid. The precipitate that formed was filtered off. Column chromatography (with $CHCl_3$ as the eluent) followed by recrystallization from MeOH gave 0.23 g of product **5a** and 0.07 g (20%) of compound **7a** (see Table 1).

Ethyl 4,4,5,5,6,6,7,7,7-nonafluoro-2-(4-methoxyphenyl)-hydrazono-3-oxoheptanoate (5b). A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and oxo ester **1b** (0.33 g, 1 mmol) gave 0.38 g of product **5b** (see Table 1).

Ethyl 4,4,5,5,6,6,7,7,7-nonafluoro-2-(4-methylphenyl)-hydrazono-3-oxoheptanoate (5c). A similar procedure starting from *p*-toluidine (0.12 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and oxo ester **1b** (0.33 g, 1 mmol) gave 0.34 g of compound **5c** (see Table 1).

Methyl 4,4,4-trifluoro-2-(4-methoxyphenyl)hydrazono-3-oxobutyrate (5d). A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and chelate **3a** (0.20 g, 1 mmol) gave 0.22 g of compound **5d** (see Table 1).

Methyl 4,4,5,5,6,6,6-heptafluoro-2-(4-methoxyphenyl)-hydrazono-3-oxoheptanoate (5e). A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and chelate **3b** (0.30 g, 1 mmol) gave 0.32 g of product **5e** (see Table 1).

1,1,1-Trifluoro-3-(4-methoxyphenyl)hydrazonopentane-2,4-dione (6a). *A.* A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and diketone **2a** (0.15 g, 1 mmol) gave 0.20 g of product **6** and 0.08 g of compound **7b** (see Table 1).

B. A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and chelate **4a** (0.18 g, 1 mmol) gave 0.14 g (50%) of product **6a**.

5,5,6,6-Tetrafluoro-3-(4-methoxyphenyl)hydrazonohexane-2,4-dione (6b). A similar procedure starting from *p*-anisidine (0.14 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and diketone **2b** (0.19 g, 1 mmol) gave 0.27 g of product **6b** (see Table 1).

5,5,6,6-Tetrafluoro-3-(4-methylphenyl)hydrazonohexane-2,4-dione (6c). A similar procedure starting from *p*-toluidine (0.12 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and diketone **2b** (0.19 g, 1 mmol) gave 0.24 g of compound **6c** (see Table 1).

5,5,6,6-Tetrafluoro-3-phenylhydrazonohexane-2,4-dione (6d). A similar procedure starting from aniline (0.1 g, 1.1 mmol), $NaNO_2$ (0.08 g, 1.1 mmol), and diketone **2b** (0.19 g, 1 mmol) gave 0.22 g of product **6d** (see Table 1).

4-(4-Methoxyphenyl)hydrazono-3-nonafluorobutyl-1*H*-pyrazolin-5-one (8). Solutions of arylhydrazone **5b** (0.47 g, 1 mmol) and $NH_2NH_2 \cdot HCl$ (0.4 g, 8 mmol) in diethyl ether were mixed, and the reaction mixture was kept for 10 min at –20 °C. The ether was evaporated. The precipitate was recrystallized from hexane and dried *in vacuo* to give 0.35 g of compound **8** (see Table 1).

4-(4-Methoxyphenyl)hydrazono-3-trifluoromethylisoxazolin-5-one (9). A mixture of arylhydrazone **5a** (0.32 g, 1 mmol), $NH_2OH \cdot H_2O$ (0.28 g, 4 mmol), and AcONa (0.2 g, 2.5 mmol) in MeOH (20 mL) was refluxed for 3 h. After cooling, the reaction mixture was diluted with water (50 mL). The precipitate that formed was filtered off, washed with water, recrystallized from benzene, and dried *in vacuo* to give 0.28 g of product **9** (see Table 1).

4-(4-Methoxyphenyl)azo-5-methyl-3-(1,1,2,2-tetrafluoroethyl)pyrazole (10a). A mixture of arylhydrazone **6b** (0.32 g, 1 mmol) and $NH_2NH_2 \cdot H_2O$ (0.2 g, 0.4 mmol) in 10 mL of glacial AcOH was refluxed for 2.5 h. The reaction mixture was cooled and diluted with 50 mL of water. The precipitate that formed was filtered off, washed with water, recrystallized from benzene, and dried *in vacuo* to give 0.26 g of product **10a** (see Table 1).

5-Methyl-4-phenylazo-3-(1,1,2,2-tetrafluoroethyl)pyrazole (10b). Similar procedure starting from arylhydrazone **6d** (0.3 g, 1 mmol) and $NH_2NH_2 \cdot H_2O$ (0.2 g, 4 mmol) gave 0.23 g of compound **10b** (see Table 1).

4-(4-Methoxyphenyl)azo-5-methyl-1-phenyl-3-(1,1,2,2-tetrafluoroethyl)pyrazole (11). A mixture of arylhydrazone **6b** (0.32 g, 1 mmol), $PhNHNH_2 \cdot HCl$ (0.58 g, 4 mmol), and NaOAc (0.21 g, 2.5 mmol) in MeOH (20 mL) was refluxed for 2 h, cooled, and diluted with water (50 mL). The precipitate that formed was filtered off, washed with water, recrystallized from acetic acid, and dried *in vacuo* to give 0.32 g of product **11** (see Table 1).

3-Hydroxy-4-(4-methoxyphenyl)azo-5-methyl-3-(1,1,2,2-tetrafluoroethyl)-1-thiocarbamoylpyrazoline (12). A mixture of arylhydrazone **6b** (0.32 g, 1 mmol) and thiosemicarbazide (0.36 g, 4 mmol) was refluxed for 50 h in a benzene—DMSO mixture (3 : 1). The benzene was evaporated. The product was precipitated from the DMSO by adding distilled water. The precipitate was filtered off, recrystallized from $CHCl_3$, and dried *in vacuo* to give 0.33 g of compound **12** (see Table 1).

3-Hydroxy-5-methyl-4-(4-methylphenyl)azo-3-(1,1,2,2-tetrafluoroethyl)isoxazoline (13). A similar procedure starting from arylhydrazone **6c** (0.3 g, 1 mmol), $NH_2OH \cdot HCl$ (0.28 g, 4 mmol), and NaOAc (0.2 g, 2.5 mmol) gave 0.25 g of compound **13** (see Table 1).

This study was financially supported by the Russian Foundation for Basic Research (Project No. 95-03-08345a).

References

1. *Comprehensive Organic Chemistry*, Eds. D. Barton and W. D. Ollis, Pergamon Press, New York, 1979, **2**, 734 pp.
2. A. Mitchell and D. C. Nonhebel, *Tetrahedron*, 1979, **35**, 2013.
3. A. T. Prudchenko, G. S. Shchegoleva, V. A. Barkhash, and N. N. Vorozhtsova, *Zh. Obshch. Khim.*, 1967, **37**, 2487 [*J. Gen. Chem. USSR*, 1967, **37** (Engl. Transl.)].
4. A. F. Shivanyuk, L. S. Kudryavtseva, M. O. Lozinskii, V. M. Neplyuev, Yu. A. Fialkov, and A. G. Bratolyubova, *Ukr. Khim. Zh.* [*Ukrainian Chemical Journal*], 1981, **47**, 1078 (in Russian).
5. K. I. Pashkevich, V. I. Saloutin, and I. Ya. Postovskii, *Usp. Khim.*, 1981, **50**, 325 [*Russ. Chem. Rev.*, 1981, **50** (Engl. Transl.)]; K. I. Pashkevich and V. I. Saloutin, *Usp. Khim.*, 1985, **54**, 1997 [*Russ. Chem. Rev.*, 1985, **54** (Engl. Transl.)].
6. L. A. Kazitsina and N. B. Kupletskaya, *Primenenie UF-, IK-, YaMR- i mass-spektroskopii v organicheskoi khimii* [*Application of UV, IR, NMR, and Mass Spectroscopy in Organic Chemistry*], Moskovskii Universitet, Moscow, 1979 (in Russian).
7. K. I. Pashkevich, Z. E. Skryabina, and V. I. Saloutin, *Izv. Akad. Nauk SSSR, Ser. Khim.*, 1987, 2527 [*Bull. Acad. Sci. USSR, Div. Chem. Sci.*, 1987, **36**, 2347 (Engl. Transl.)]; Z. E. Skryabina, Ya. V. Burgart, and V. I. Saloutin, *Zh. Org. Khim.*, 1997, **33**, 442 [*Russ. J. Org. Chem.*, 1997, **33** (Engl. Transl.)].
8. A. W. Nineham, *Chem. Rev.*, 1955, **55**, 355.

Received September 26, 1997