SYNTHESIS OF RING-SUBSTITUTED PHENYL HYDRAZINECARBOXYLATES AND STUDY OF THEIR PROTONATION IN DIMETHYL SULFOXIDE SOLUTIONS

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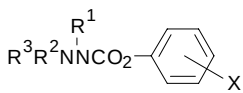
Received July 7, 1997
Accepted February 24, 1998

The pK_a values of nineteen phenyl hydrazinecarboxylate hydrochlorides R-$C_6H_4OCONHNH_2$·HCl (R = H, 3- and 4-Cl, 3- and 4-O_2N, 4-Me) and their 1-methyl or 2-methyl derivatives were determined by potentiometric titration with tetrabutylammonium hydroxide in DMSO. IR spectra of the hydrazinecarboxylates and their hydrochlorides revealed that the hydrazinecarboxylate protonation occurs at N^2. The methods of synthesis of phenyl hydrazinecarboxylate and their *N*-methyl derivatives were optimized.

Key words: Aryl hydrazinecarboxylates; Acidity constants.

Phenyl hydrazinecarboxylates **1a–5a** are bioactive substances which are hydrolytically degraded in living organisms. Previously[1], we examined the kinetics and mechanism of alkaline hydrolysis of the substances whose general formula is given below.



	R^1	R^2	R^3
1	H	H	H
2	H	Me	Me
3	Me	H	H
4	Me	Me	H
5	Me	Me	Me

In formulae **1**-**5** : **a**, X = H; **b**, X = 3-Cl; **c**, X = 4-Cl; **d**, X = 3-NO_2; **e**, X = 4-NO_2; **f**, X = 4-Me; **g**, X = 4-OMe

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We found that the reactivity and degradation pathway are substantially affected by the presence or absence of hydrogen in the R^1 position, capable of ionizing (K_a1) in the presence of bases. During the synthesis of the substances, we observed that many of them can be isolated from solutions in aprotic solvents as stable hydrochlorides **1a**·HCl–**5a**·HCl. The hydrochlorides can be converted back to the starting hydrazinecarboxylates by alkalization* (equilibrium K_a2), as shown in Scheme 1.

$$[R^3R^2N\overline{N}CO_2C_6H_4X]^- \xrightleftharpoons[(R^1 = H)]{-H^+/NaOH,\ K_a1} \underset{\textbf{1a–5a}}{R^3R^2NN(R^1)CO_2C_6H_4X} \xrightleftharpoons{-H^+/HCl,\ K_a2} \underset{\textbf{1a}\cdot HCl–\textbf{5a}\cdot HCl}{[R^3R^2NN(R^1)CO_2C_6H_4X]\cdot H^+}$$

SCHEME 1

The present paper describes the results of study of protonation of hydrazinecarboxylates **1a–5a**, paying attention to the site where the reaction occurs and how the equilibrium K_a2 is affected by the structure of the substance. We also optimized the synthesis of phenyl hydrazinecarboxylate because the only published route[2] fails to provide satisfactory yields. This topic was not addressed by our previous paper.

Phenyl Hydrazinecarboxylate Protonation

Phenyl hydrazinecarboxylate hydrochlorides are little soluble in aprotic solvents, while in water, in which they are well soluble, hydrolysis and decarboxylation to phenols and hydrazinium salts takes place. Therefore, we examined the acid-based equilibria of the phenyl hydrazinecarboxylates in anhydrous dimethyl sulfoxide (DMSO), where the protonation equilibrium is unaffected by hydrolysis; at the same time, this approach enabled us to follow up the work of Koppel and others[3] who examined similar equilibria of hydrazine and amines in DMSO. Phenyl hydrazinecarboxylates contain basic centres at N^1 and N^2 and at the two oxygen atoms, which must be considered in deducing the structure of the hydrochlorides.

The protonation was studied by examined the IR spectra of the model substances **1a**·HCl, **2a**·HCl and **4a**·HCl and comparing them with those of the bases **1a**, **2a** and **4a**. On the protonation of hydrazinecarboxylates **1a**, **2a** and **4a**, the original ^{1}H NMR signals of both the N–H groups vanish. In the IR spectra of the dimethyl derivatives **2a** and **4a**, the absorption bands of the N^1H and N^2H groups lie at 3 250 cm^{-1} and 3 330 cm^{-1}.

* The equations (*3*) were presented in a wrong form in ref.[1]. The correct one is as follows: $\log k_{obs} = pH + \log k_2K_w = pH + \log k_1K_a = pH + \log k_{OH} - 14$.

Table I gives the corresponding wavenumbers for the N–D groups in the deuterated derivatives. The ν(NH)/ν(ND) ratio is 1.34 to 1.35. The IR spectra of the substances **1a**·HCl and **2a**·HCl exhibit broad diffuse bands of the associated $^{+}N^{2}H$ groups within the range of approximately 3 200–2400 cm^{-1}. The salts **1a**·HCl, **2a**·HCl and **4a**·HCl differ in the number of hydrogen atoms at the N^2 atom (3, 2 and 1, respectively), and are consistent with the corresponding primary, secondary and tertiary amine salts, whose spectra are identical within the above region[4]. The set of intense δ($^{+}N^{2}H_3$) bands within the 1 600–1 500 cm^{-1} region for **1a**·HCl, and the weak δ($^{+}N^{2}MeH_2$) band for **2a**·HCl can be attributed to the bending vibrations of the hydrochlorides.

Table I also summarizes the wavenumbers of the hydrazinecarboxylate carbonyl group bands for **1a**, **2a** and **4a**. The spectrum of the 2,2-dimethyl derivative **2a**, however, exhibits three ν(C=O) bands but a single ν(N^1H) band. In carbon tetrachloride solution, this substance displays a medium-intensity band with two shoulders, which we took into account. In this case, we failed to decide whether these are due to a mixture of conformers or to vibrational interactions. The strong ν(C–O) band lies at 1 211–1 212 cm^{-1}. Due to the –I effect of the positively charged N^2, the carbonyl wavenumber for the hydrochlorides is shifted upwards by 20–43 cm^{-1} (Table I). Proton exchange in the related hydrazides takes place mainly at the N^2 atom, as found by variation of substituents in the benzene rings at N^1 and N^2 (refs[5,6]).

We found that with respect to its pK_a2 value (pK_a2 = 5.24, see Table II), phenyl hydrazinecarboxylate hydrochloride **1a**·HCl is roughly a ten times weaker acid than hydrazine dihydrochloride (4.0), whose value has been determined by Koppel and coworkers[3].

TABLE I
IR wavenumbers (cm^{-1}) of phenyl hydrazinecarboxylates **1a–4a**, their deuterated analogs and hydrochlorides[a]

Compound	ν(N^1H)	ν(N^2H)	ν(N^1D)	ν(N^1D)	ν(C=O)	Compound	ν(N^2H)	ν(C=O)
1a	3 260 w	3 338 s 3 319 m	2 408 w	2 500 w 2 480 w	1 715 vs 1 745 vs[b]	**1a**·HCl	3 120–2 660 sb	1 763 vs
2a	3 250 m		2 420 w		1 726 v 1 740 sh[c] 1 740 m 1 760 vs[c] 1 758 s 1 775 sh[c]	**2a**·HCl	3 120–2 655 sb	1 749 vs
4a		3 330 wb		2 470 wb	1 727 vs	**4a**·HCl	3 232–2 435 sb	1 747 vs

[a] Solid phase (Nujol mulls, KBr disks); [b] chloroform; [c] tetrachloromethane.

The presence of methyl groups at nitrogen atoms in hydrazinecarboxylates **12a**·HCl–**5a**·HCl reduces the acidity in the order H_2NNHCO_2Ph·HCl (**1a**·HCl) ≅ Me_2NNCO_2Ph·HCl (**2a**·HCl) > $H_2NNMeCO_2Ph$·HCl (**3a**·HCl) > $MeNHNMeCO_2Ph$·HCl (**4a**·HCl) > $Me_2NNMeCO_2Ph$·HCl (**5a**·HCl). This order is not in accord with the acidity order of the respective methylated hydrazine dihydrochlorides, whose acidities are enhanced by each introduced methyl group[7], $MeNHNMe_2$·HCl > Me_2NNH_2·HCl > $Me_2NHNHMe$·HCl > $MeNHNH_2$·HCl > NH_2NH_2HCl·HCl and, rather, approaches the acidity order of the ammonium and alkylammonium ions[8], $NH_4^+ > Me_3N^+ > MeNH_2^+ > Me_2NH^+$. The acid-base properties of the last-mentioned series have been explained in terms of a simple combination of electronic and steric effects, whereas for the methylhydrazine series, no satisfactory explanation is available.

In the phenyl hydrazinecarboxylate series, the acidity of the hydrazinecarboxylate hydrochlorides (**1a–2g**)·HCl is enhanced by the presence of electronegative substituents. We determined the sensitivity of the protonation equilibrium pK_a2 to the phenyl ring substitution in DMSO solution on the basis of the reaction constants ρ in the Hammett equation for our experimental acidity constants pK_a in the hydrazinecarboxylate hydrochlorides series (**1–3**)·HCl (Table II). The values are ρ = 0.80 ± 0.21, 0.52 ± 0.10 and 0.09 ± 0.04 for the series (**1a–1f**)·HCl (**2a–2g**)·HCl and (**3a–3f**)·HCl, respectively. Although the standard deviations are considerable, it is clear that the ρ values are rather high, especially for the two former series. The values suggest that the conformation, where the proton at N^2 can be simultaneously attracted by electrons of the C=O group in anion-bonding interaction, may be the predominating phenomenon.

Phenyl Hydrazinecarboxylate Synthesis

When reproducing the preparation procedure for phenyl hydrazinecarboxylate **1a** as reported by Merck[2] by hydrazinolysis of diphenyl carbonate in ethanol, we obtained the

TABLE II
pK_a2 values of phenyl hydrazinecarboxylate hydrochlorides and their 1-methyl and 2-methyl derivatives in DMSO at 25 °C (standard deviations are given in parentheses)

Compound	pK_a2	Compound	pK_a2	Compound	pK_a2	Compound	pK_a2
1a·HCl	5.24(0.05)	**2a**·HCl	5.21(0.04)	**2g**·HCl	5.30 (0.10)	**3f**·HCl	5.68(0.07)
1b·HCl	4.75(0.06)	**2b**·HCl	5.00(0.05)	**3a**·HCl	5.57(0.06)	**4a**·HCl	5.42(0.05)
1c·HCl	4.71(0.07)	**2c**·HCl	5.22(0.07)	**3b**·HCl	5.54(0.07)	**5a**·HCl	5.51(0.10)
1d·HCl	4.69(0.09)	**2d**·HCl	4.89(0.05)	**3c**·HCl	5.48(0.05)		
1e·HCl	4.56(0.02)	**2e**·HCl	4.80(0.10)	**3d**·HCl	5.48(0.09)		
1f·HCl	5.41(0.11)	**2f**·HCl	5.28(0.11)	**3e**·HCl	5.50(0.08)		

TABLE III
Analytical data of hydrazinecarboxylates $R^3R^2NN(R^1)CO_2C_6H_4X$ (procedure *A*) and their hydrochlorides

Compound	R^1, R^2 R^3, X	M.p., °C Yield, %	Formula M.w.	Calculated/Found			Adduct M.p., °C
				% C	% H	% N	
1a	H, H	104–105[a]	$C_7H_8N_2O$	–	–	–	**1a**·HCl
	H, H	45, 10[b]	151.2				179–181
1b	H, H	110–111	$C_7H_7ClN_2O_2$	45.06	3.76	15.01	**1b**·HCl
	H, 3-Cl	88	186.6	45.12	3.86	15.16	183–185
1c	H, H	139–141	$C_7H_7ClN_2O_2$	45.06	3.76	15.01	**1c**·HCl
	H, 4-Cl	42	186.6	45.33	3.68	14.78	203–205
1d	H, H	121–123	$C_7H_7N_3O$	42.65	3.58	21.31	**1d**·HCl
	H, 3-NO_2	82	197.1	42.34	3.60	21.06	147–149
1e	H, H	111–113	$C_7H_7N_3O$	42.65	3.58	21.31	**1e**·HCl
	H, 4-NO_2	78	197.1	42.90	3.73	21.12	149–151
1f	H, H	115–117	$C_8H_{10}N_2O_2$	57.82	6.07	16.86	**1f**·HCl
	H, 4-Me	40, 14[b]	166.1	57.56	6.41	16.83	191–193
2a	H, Me	69.5–71[c]	$C_9H_{12}N_2O$	–	–	–	**2a**·HCl
	Me, H	28	180.2				113–115
2b	H, Me	88–90	$C_9H_{11}ClN_2O_2$	50.32	5.17	13.06	**2b**·HCl
	Me, 3-Cl	54	214.6	50.11	4.92	13.40	135–139
2c	H, Me	129–131	$C_9H_{11}ClN_2O_2$	50.32	5.17	13.06	**2c**·HCl
	Me, 4-Cl	41	214.6	50.07	5.23	13.25	154–155
2d	H, Me	110–112	$C_9H_{11}N_3O_4$	48.00	4.92	18.66	**2d**·HCl
	Me, 3-NO_2	39	225.2	48.22	4.92	18.59	151–152
2e	H, Me	118–120	$C_9H_{11}N_3O_4$	48.00	4.92	18.66	**2e**·HCl
	Me, 4-NO_2	56	225.2	47.96	4.91	18.52	145–147
2f	H, Me	124–126	$C_{10}H_{14}N_2O_2$	61.84	7.27	14.43	**2f**·HCl
	Me, 4-Me	21	194.2	61.86	7.26	14.72	143.5–145
2g	H, Me	102–103	$C_{10}H_{14}N_2O_3$	57.14	6.71	13.33	**2g**·HCl
	Me, 4-OMe	15	210.2	56.97	6.81	13.31	141–143
3a	Me, H	[d]	$C_8H_{10}N_2O_2$	57.82	6.07	16.86	**3a**·HCl
	H, H	35	166.1	57.49	6.18	16.56	162–164[e]

TABLE III
(*Continued*)

Compound	R^1, R^2 R^3, X	M.p., °C Yield, %	Formula M.w.	Calculated/Found % C	% H	% N	Adduct M.p., °C
3b	Me, H	31–34[f]	$C_8H_9ClN_2O_2$	47.89	4.53	13.96	**3b**·HCl
	H, 3-Cl	42	200.6	48.14	4.60	13.68	146–148
3c	Me, H	161–163	$C_8H_9ClN_2O_2$	47.89	4.53	13.96	**3c**·HCl
	H, 4-Cl	50, 15[b]	200.6	47.95	4.70	13.74	155–157
3d	Me, H	83–88 (dec)	$C_8H_9N_3O_4$	45.50	4.30	19.90	**3d**·HCl
	H, 3-NO_2	38	211.1	45.76	4.32	19.89	136.5–138
3e	Me, H	93–97 (dec)	$C_8H_9N_3O_4$	45.50	4.30	19.90	**3e**·HCl
	H, 4-NO_2	47	211.1	45.42	4.47	20.14	150–152
3f	Me, H	[g]	$C_9H_{12}N_2O_2$	59.99	6.71	15.55	**3f**·HCl
	Me, 4-Me	23	180.2	60.21	6.60	15.27	164–166
4a	Me, Me	[h]	$C_9H_{12}N_2O_2$	59.99	6.71	15.55	**4a**·HCl
	H, H	42	180.2	59.42	6.51	15.12	144–146
5a	Me, Me	[i]	$C_{10}H_{14}N_2O_2$	61.84	7.27	14.42	**5a**·HCl
	Me, H	27	194.2	62.12	7.33	14.09	103–105

[a] Ref.[1] gives for **1a** m.p. 105 °C; [b] see procedure *B*; [c] ref.[2] gives for **2a** m.p. 75–77 °C; [d] for **3a** b.p. 155–157 °C/1.3 kPa, n_D^{20} 1.5298; [e] ref.[9] gives for **3a**·HCl m.p. 165–167 °C; [f] for **3b** b.p. 123–125 °C/0.1 kPa; [g] for **3f** b.p. 110–115 °C/0.1 kPa; [h] for **4a** b.p. 102–103 °C/0.4 kPa, n_D^{20} 1.5230; [i] for **5a** b.p. 94–97 °C/0.4 kPa, n_D^{20} 1.5148.

product in a yield as low as 10% see Experimental, procedure *A*). The procedure applied to the preparation of substance **2f** and **3c** resulted in similarly low yields (Table III). If ethanol was replaced by diethyl ether and the reaction components were stirred at –35 °C (procedure *B*), hydrazinecarboxylates **1a–1f** separated from the solutions as crystalline substances when keeping the reaction mixture at room temperature. The hydrazinecarboxylates **3a–4a** were prepared by a similar procedure (*C*). The yields, ranging from 40 to 88%, are given in Table III along with the elemental analysis data and physical constants. The starting diphenyl carbonates were prepared in yields exceeding 90% by a new phosgene-free single-step method reacting the corresponding phenol with trichloromethyl chloroformate in the presence of triethylamine.

Substituted phenyl 2,2-dimethylhydrazinecarboxylates (**2a–2g**) and phenyl 1,2,2-trimethylhydrazinecarboxylate (**5a**) were obtained by reacting aryl chloroformates with an excess of 1,1-dimethylhydrazine and 1,1,2-trimethylhydrazine, respectively, follow-

ing procedure *D*. The yields, along with the elemental analysis data, are given in Table III. On analogous reaction of hydrazine with phenyl chloroformates (which are more reactive than diphenyl carbonate) in the presence of sodium carbonate gives diphenyl hydrazine-1,2-dicarboxylate[9]. We found that this is the sole product at –60 °C even if hydrazine is present in excess. This substance is also formed in aqueous formate buffer, where hydrazine is mostly present as monohydrochloride (procedure *F*).

Reaction of phenyl chloroformate and hydrazine monohydrochloride in DMSO gives roughly the same amount of hydrazinecarboxylate as hydrazine-1,2-dicarboxylate; this is also true for the water-containing heterogeneous system (procedure *G*).

EXPERIMENTAL

The melting points were measured on a Kofler stage and have not been corrected. The IR spectra were measured in Nujol mulls (**1a–5a**), in KBr disks (**1a**·HCl, **2a**·HCl), in melts and in chloroform or carbon tetrachloride solutions on a Zeiss IR-75 spectrophotometer. The ^{1}H and ^{13}C NMR spectra in deuteriochloroform or hexadeuteriodimethyl sulfoxide were scanned at 25 °C on a Bruker AMX-360 instrument. The chemical shifts are given relative to the solvent signals (for hexadeuteriodimethyl sulfoxide, $\delta(^{1}H)$ 2.55, $\delta(^{13}C)$ 39.6). The purity of the hydrazinecarboxylates was assessed chromatographically on a Varian HPLC Model 5000 using a Separon SGX C1 column (80% aqueous methanol), and on a GC Chrom-5 apparatus (Laboratorni pristroje Praha) in a 1-m column packed with Chromosorb A (60/80 mesh)–10% SE52, using FID and nitrogen as carrier gas.

The equilibria of the phenyl hydrazinecarboxylates **1a–5a** and their hydrochlorides (**1a–5a**)·HCl were measured by potentiometric titration of solutions (5 mmol l^{-1}) of the hydrochlorides in anhydrous dimethyl sulfoxide with 0.1 M methanolic solution of tetrabutylammonium hydroxide under argon at 25 °C, using a Radiometer Titrilab 3 instrument. For nitrophenyl hydrazinecarboxylate hydrochlorides, where hydrolysis takes place in the presence of an excess of the titrant, the pK_a2 values were determined by titrating phenyl hydrazinecarboxylates **1d**, **1e**, **2d** and **2e** in DMSO with an alcoholic solution of hydrogen chloride. The pK_a1 values of (**1a–1e**)·HCl are given in Table II. The equilibria were characterized by a single potentiometric wave within the pH region from 4.4 to 5.7 and compared with the pK_a value of benzoic acid (11.8) and the first wave of hydrazine dihydrochloride pK_a1 (4.0, ref.[3]).

Aryl Hydrazinecarboxylates **1a–1f**

Procedure A. To a solution of a diphenyl carbonate (20 mmol) in diethyl ether (30 ml), 85% hydrazine hydrate (20 mmol)) was portionwise added at 0 °C within 5 min. The reaction was allowed to proceed for 30 min, after which the mixture was concentrated to 20% volume. The crude product was separated from the solution by cooling with ice. The yields of hydrazinecarboxylates **1a**, **1f** and **3c** obtained are given in Table III.

Procedure B. To a stirred solution of a diphenyl carbonate (20 mmol) in diethyl ether (30 ml), cooled to –35 °C, 85% hydrazine hydrate (20 mmol) was added in one portion. The mixture was warmed to room temperature and allowed to stand for another 20 min. The crude hydrazinecarboxylate crystals were filtered off and recrystallized from a hexane–benzene 1 : 1 mixture. The yields, physical properties and elemental analysis data are given in Table IV.

Procedure C. This procedure was applied to the phenyl 1-methylhydrazinecarboxylates **3a–3f** and phenyl 1,2-dimethylhydrazinecarboxylate **4f**. To a stirred solution of the corresponding hydrazine (20 mmol) in ether (15 ml), cooled to –35 °C, a solution of a diphenyl carbonate (20 mmol) in the same solvent

TABLE IV
^{1}H NMR data of phenyl hydrazinecarboxylates (chemical shifts in ppm (δ-scale), *J* in Hz)

Compound	^{1}H NMR ($CDCl_3$), δ (ppm), *J* (Hz)
1a	3.71 b, 2 H (H-8); 6.46 b, 1 H (H-7); 7.12 d, 2 H, *J* = 7.6 (H-2, H-6); 7.20 t, 1 H, *J* = 7.4 (H-4); 7.35 t, 2 H, *J* = 8.0 (H-3, H-5)
1b[a]	6.77 m, 1 H (H-6); 6.85 m, 2 H (H-2, H-4); 7.23 t, 1 H, *J* = 7.9 (H-5)
1c	3.84 b, 2 H (H-9); 6.37 b, 1 H (H-7); 7.06 d, 2 H, *J* = 8.8 (H-2, H-6); 7.32 d, 2 H, *J* = 8.8 (H-3, H-5)
1d[a]	7.26 m, 1 H (H-6); 7.51 t, 1 H, *J* = 8.14 (H-5); 7.60 t, 1 H, *J* = 2.0 (H-2); 7.70 m, 1 H (H-4)
1e[a]	6.97 d, 2 H, *J* = 9.2 (H-2, H-6); 8.16 d, 2 H, *J* = 9.2 (H-3, H-5)
1f	2.31 s, 3 H (H-11); 3.68 b, 2 H (H-9); 6.49 b, 1 H (H-7); 6.97 d, 2 H, *J* = 8.1 (H-2, H-6); 7.12 d, 2 H, *J* = 8.1 (H-3, H-5)
2a	2.64 s, 6 H (H-11); 6.09 b, 1 H (H-7); 7.12 m, 2 H (H-2, H-6); 7.17 t, 1 H, *J* = 7.15 (H-4); 7.34 t, 2 H, *J* = 7.6 (H-3, H-5)
2b	2.65 s, 6 H (H-10); 6.04 b, 1 H (H-7); 6.78 m, 1 H (H-6); 6.87 m, 2 H (H-2, H-4); 7.25 t, 1 H, *J* = 7.9 (H-5)
2c	2.65 s, 6 H (H-10); 6.05 b, 1 H (H-7); 7.06 d, 2 H, *J* = 8.75 (H-2, H-6); 7.29 d, 2 H, *J* = 8.75 (H-3, H-5)
2d[a]	2.45 s, 6 H (H-10); 7.16 b, 1 H (H-7); 7.26 m, 1 H (H-6); 7.50 t, 1 H, *J* = 8.15 (H-5); 7.60 t, 1 H, *J* = 2.2 (H-2); 7.70 m, 1 H (H-4)
2e[a]	2.45 s, 6 H (H-10); 6.97 m, 2 H (H-2, H-6); 7.17 b, 1 H (H-7); 8.16 m, 2 H (H-3, H-5)
2f	2.31 s, 3 H (H-11); 2.68 s, 6 H (H-10); 6.99 d, 2 H, *J* = 8.3 (H-2, H-6); 7.13 d, 2 H, *J* = 8.3 (H-3, H-5)
2g	2.66 s, 6 H (H-10); 3.76 s, 3 H (H-11); 6.84 m, 2 H (H-3, H-5); 7.03 d, 2 H, *J* = 8.6 (H-2, H-6)
3a	3.22 b, 3 H (H-8); 3.99 b, 2 H (H-10); 7.09 m, 2 H (H-2, H-6); 7.17 t, 1 H *J* = 7.2 (H-4); 7.33 t, 2 H, *J* = 7.5 (H-3, H-5)
3b	3.24 b, 3 H (H-8); 4.18 b, 2 H (H-9); 7.01 m, 2 H (H-6); 7.15 t, 1 H, *J* = 2.0 (H-2); 7.18 m, 1 H (H-4); 7.27 t, 1 H (H-5)
3c	3.24 b, 3 H (H-7); 4.16 b, 2 H (H-9); 7.04 d, 2 H, *J* = 8.8 (H-2, H-6); 7.28 d, 2 H, *J* = 8.8 (H-3, H-5)
3d[a]	3.14 b, 3 H (H-8); 4.11 b, 2 H (H-9); 7.24 m, 1 H (H-6); 7.49 t, 1 H, *J* = 8.2 (H-5); 7.59 t, 1 H, *J* = 2.1 (H-2); 7.71 m, 1 H (H-4)
3e[a]	3.14 b, 3 H (H-8); 4.12 b, 2 H (H-9); 7.14 d, 1 H, *J* = 9.1 (H-2, H-6); 8.19 d, 1 H, *J* = 9.1 (H-3, H-5)
3f	2.30 s, 3 H (H-11); 3.20 b, 3 H (H-8); 4.19 b, 2 H (H-9); 6.96 m, 2 H (H-2, H-6); 7.11 m, 2 H (H-3, H-5)
4a	2.65 b, 3 H (H-10); 3.21 b, 3 H (H-8); 4.13 b, 1 H (H-8); 7.12 m, 2 H (H-2, H-4); 7.18 t, 1 H, *J* = 7.4 (H-4); 7.35 t, 2 H (H-3, H-5)
5a	2.64 b, 6 H (H-10); 2.97 b, 3 H (H-8); 7.11 m, 2 H (H-2, H-6); 7.16 t, 1 H, *J* = 7.3 (H-4); 7.32 t, 2 H, *J* = 8.0 (H-3, H-5)

[a] In $(CD_3)_2SO$.

(20 ml) was added over a period of 15 min. The mixture was warmed to room temperature, allowed to stand for another 40 min, and then the system was bubbled with dry hydrogen chloride for 10 min. The solid separated was filtered off and washed with ether (30 ml). The substance was dispersed in ether (30 ml) and on aqueous solution of potassium carbonate (12 mmol) was added portionwise to the stirred mixture within 15 min. The organic phase was evaporated, the crude product was distilled in vacuum and then crystallized from a hexane–benzene 1 : 1 mixture. The results, along with elemental analysis and physical data, are given in Table III, the NMR spectral data are given in Table IV.

Preparation of Diphenyl Carbonates from Trichloromethyl Chloroformate and Phenols

To a stirred solution containing phenol (1.9 g, 20 mmol) and triethylamine (2.0 g, 20 mmol) in tetrahydrofuran (20 ml), a solution of trichloromethyl chloroformate (1.0 g, 5 mmol) in tetrahydrofuran (5 ml) was added dropwise within 5 min. The stirred mixture was heated to the boil for 10 min, cooled, and mixed with water (100 ml). The solid (2.0 g, 93%) was filtered off, washed with water, and crystallized from methanol; m.p. 79–80 °C. The same procedure was applied to the synthesis of the diphenyl carbonates substituted in positions 3 or 4 by a chloro, nitro, methyl or ethoxy group; the yields ranged from 91% to 95%.

Procedure *D*. Preparation of Phenyl 2,2-Dimethylhydrazinecarboxylates **2a–2g** and Phenyl 1,2,2-Trimethylhydrazinecarboxylate **5a** from Phenyl Chloroformates

The substances were prepared from the corresponding hydrazine (20 mmol) in ether (20 ml) by adding, under stirring at –35 °C, a solution of a phenyl chloroformate (10 mmol) within 10 min. After 30 min, the separated 2,2-dimethyl- or 1,1,2-trimethylhydrazine hydrochloride was filtered off and the product was isolated either by vacuum distillation or by recrystallization from a petroleum ether–propan-2-ol mixture. The yields and physicochemical properties are given in Table III, the spectral characteristics in Table IV.

Procedure E. To a stirred emulsion of 99% hydrazine hydrate (0.5 ml, 10 mmol) in chloroform (5 ml), cooled to –60 °C, a solution of phenyl chloroformate (0.63 ml, 5 mmol) in the same solvent (3 ml) was added within 5 min. After warming up to room temperature, the mixture was shaken with water, the organic solution was dried and the solvent was removed by vacuum distillation. The solid (0.5 g) was crystallized from toluene; m.p. 154–156 °C.

Procedure F. To a stirred mixture of hydrazine dihydrochloride (0.52 g, 5 mmol) in water (5 ml) and phenyl chloroformate (0.78 g, 5 mmol) in dichloromethane (10 ml), a solution of sodium formate (2.5 g, 30 mmol) in water (10 ml) was portionwise (over a period of 15 h) added at 10 °C. The mixture was allowed to warm up to room temperature and allowed to stand for another 8 h. The organic phase was separated, dried with anhydrous sodium sulfate, and the solvent was removed by evaporation in vacuum. The residue (0.35 g) was crystallized from toluene; m.p. 155–156 °C. The same procedure was used when adding potassium hydrogencarbonate (1.5 g, 15 mmol) instead of sodium formate; the product yield was 0.6 g, m.p. 155–156 °C.

Procedure G. To a stirred solution of hydrazine monohydrochloride (0.42 g, 4 mmol) in DMSO (6 ml), held at room temperature, phenyl chloroformate (0.25 ml, 2 mmol) in chloroform (3 ml) was dropwise added within 5 min. After 10 min, the mixture was alkalized with a saturated solution of sodium carbonate. The chloroform phase was separated, washed with water and analyzed by chromatography. The product contained compound **1a** (46%), diphenyl hydrazine-1,2-dicarboxylate (42%) and two unidentified substances.

The same procedure was performed in water; after the reaction, the mixture was allowed to stand for 24 h at room temperature. Chromatographic analysis revealed the presence of **1a** (52%), diphenyl hydrazin-1,2-dicarboxylate (41%) and one unidentified substance. ^{1}H NMR spectrum: 7.37 t, 2 H (H-3,5);

7.234 t, 21 H (H-4); 7.16 d, 2 H (H-2,6); 6.95 t, 2 H (NH). ^{13}C NMR spectrum: 154.9 (CO), 150.6 (C-1), 129.7 (C-3), 125.7 (C-4), 121.6 (C-2).

Phenyl Hydrazinecarboxylate Hydrochlorides **1a**·HCl–**5a**·HCl

Dry hydrogen chloride was introduced into a 10% solution of a phenyl hydrazinecarboxylate in diethyl ether (**1a–1c**, **1f–5a**) or in diethyl ether–dioxane 5 : 1 (**1d** and **1e**) at 0 °C. After saturation, the crystals were separated by centrifugation and purified by crystallization from toluene. The yields of the hydrochlorides were quantitative, the melting points are given in Table III.

This research work was sponsored by the Grant Agency of the Czech Republic, Grant No. 203/97/0545.

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