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PHTHALAZONE ARYLHYDRAZONES*

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UDC 547.852.7:547.574.3:543.422

The products of the reaction of 1-chloro- and 1,4-dichlorophthalazine with nitrophenylhydrazines are the E isomers of the nitrophenylhydrazones of the corresponding phthalazone. 2-Methyl-4-chlorophthalazone 4-nitrophenylhydrazone was found to be a mixture of Z and E isomers (3:2). 1,4-Dichlorophthalazine reacts with 1-methyl-1-phenyl- and 1,1-diphenylhydrazines to give monosubstitution products, for which the phthalazone hydrazone (III) or phthalazinylhydrazine (VI) form or a tautomeric mixture of III and VI is realized, depending on the nature of the solvent and other factors. Some oxidation, reduction, and nucleophilic substitution reactions of the compounds obtained are examined.

In a continuation of our research on the structures, chemical and biological properties, and isomerism of the amidrazone-hydrazinoimine type of hydrazino derivatives of phthalazine [1-6] we investigated the reactions of 1-chloro- and 1,4-dichlorophthalazines (Ia,b) with 4-nitro- (IIa), 2-nitro- (IIb), 2,4-dinitro- (IIc), 2,4,6-trinitro- (IId), 1-methyl-1-phenyl- (IIe), and 1,1-diphenylhydrazines (IIf). Replacements of the chlorine atom in 1-chlorophthalazine Ia by an arylhydrazine group proceeds smoothly and leads to IIIa-c. Both chlo-

*Communication LX from the series "Hydrazones." See [1] for communication LIX.

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0009-3122/78/1405-0575$07.50

rine atoms in 1,4-dichlorophthalazine Ib are labile [7]; however, the second chlorine atom is replaced under quite severe conditions in the reaction with hydrazine [8], and 1,4-phthalazinoquinone bis(arylhydrazones) are obtained with arylhydrazines [9]. Under mild conditions we isolated monosubstitution products IIId-f and IIIh-i, regardless of the ratio of the starting compounds. We also obtained IIIf from 4-chlorophthalazone hydrazone (IVa) by the action of 2,4-dinitrochlorobenzene. The identical character of the products indicates that the hetarylation of the arylhydrazines proceeds at the β-nitrogen atom and that the arylation of hydrazone IVa takes place at the NH_2 group of the hydrazone fragment.

Because of its low basicity, picrylhydrazine does not react with 1,4-dichlorophthalazine but does catalyze the saponification of the latter, since 4-chlorophthalazone is always formed even in absolute solvents. The ease of hydrolysis of 1,4-dichlorophthalazine in acidic media to 4-chlorophthalazone was noted in [10]. However, derivative IIIg was readily obtained by arylation of hydrazone IVa with picryl chloride.

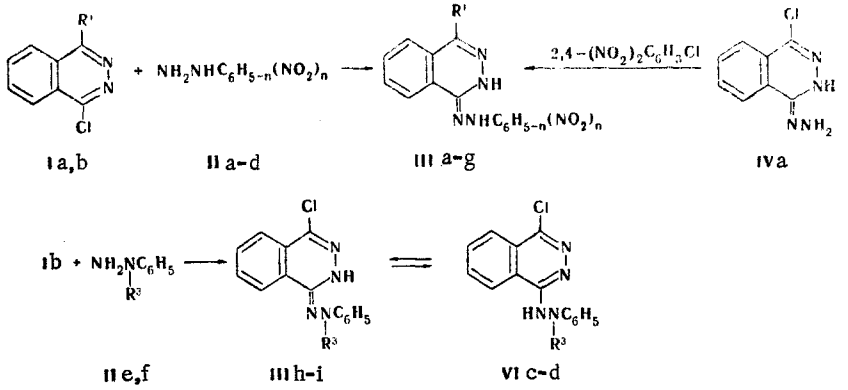
The reaction of 1-chloro- and 1,4-dichlorophthalazines with 4-nitro- and 2,4-dinitrophenylhydrazines in anhydrous solvents leads to the isolation of the hydrochlorides of IIIa,c,d,f, which lose HCl when they are treated with water.

Compounds IIIa-g are inclined toward polymorphism. The color and form of the resulting crystals often depend on the nature of the solvent and the crystallization conditions. For example, 4-nitro derivative IIId was isolated in the form of black and green crystals from dioxane, black and blue crystals from dimethyl sulfoxide (DMSO), and cherry-red crystals from alcohol; it was also isolated as a brown powder from dimethylformamide (DMF). The spectral characteristics of these forms are identical, although the IR spectra of crystalline samples (in mineral oil) have slight differences in the "fingerprint" region.

Compounds III can exist in the 1-phthalazinyl-2-arylhydrazine (VI) or phthalazone arylhydrazone (III) form. Interconversions or the realization of tautomeric equilibrium between them also are not excluded. To study this problem we compared the data from the IR, PMR, and UV spectra of IIIa-g with the analogous data for their methylated analogs with fixed arylhydrazone (Va,b) and phthalazinylhydrazine (VIb) forms (Tables 1 and 2 and Figs. 1 and 2).

Hydrazone Va was obtained by reaction of hydrazine IIa with 1,4-dichloro-2-methylphthalazinium methylsulfate. 2-Methyl-4-chlorophthalazone 2,4,6-trinitrophenylhydrazone (Vb) and 1-methyl-1-(4-chloro-1-phthalazinyl)-2-(2,4,6-trinitrophenyl)hydrazine (VIb) were synthesized by arylation of 2-methyl-4-chlorophthalazone hydrazone (IVb) and 1-methyl-1-(4-chloro-1-phthalazinyl)hydrazine (VIa) with picryl chloride.

The UV spectra of arylhydrazones Va,b in dioxane (Table 1) are similar to the spectrum of hydrazone IVb [2], but the long-wave band is shifted bathochromically as a result of participation of the π system of the aryl ring in the overall conjugation system. The decrease in the intensity of the long-wave band in the spectrum of hydrazone Vb is evidently due to rotation of the picryl group about the C-N bond.



Ia R^1 = H, b R^1 = Cl; II–IIIa 4-NO_2, b 2-NO_2, c,f 2,4-$(NO_2)_2$; IId, IIIg 2,4,6-$(NO_2)_3$, IIId 4-NO_2, e 2-NO_2; IIe, IIIh, VIc R^3 = CH_3; IIf, IIIi, VId R^3 = C_6H_5. IIIa-c R′ = H; IIId-g, R′ = Cl

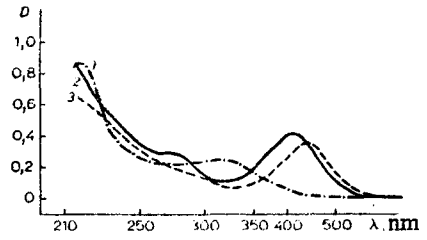


Fig. 1. UV spectra in dioxane: 1) VIb; 2) IIIg; 3) Vb.

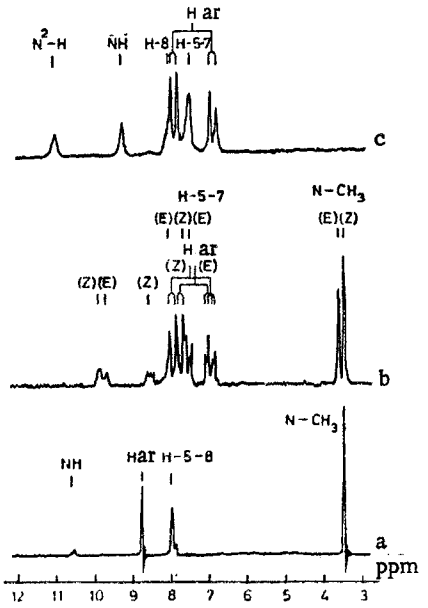


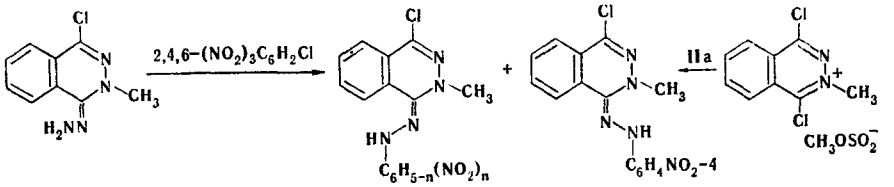
Fig. 2. PMR spectra in d_6-DMSO (a,b) and DMSO (c): a) VIb; b) Va; c) IIId.

TABLE 1. UV and IR Spectra of Arylhydrazones IIa-i and Va,b and Phthalazinylhydrazines VIb-d

Compound	λ_{max}, nm (lg ε)			ν_{max}, cm^{-1} (mineral oil)	
	dioxane	$CHCl_3$	DMSO	NH	C=N and C=C
IIIa	422 (4,32); 280 (4,04); 244 (4,18)[a]	—	—	3380, 3310	1645 (w), 1610
IIIb	418 (4,04); 328 (3,89)[a]; 290 (4,00); 252 (4,30)[a]	—	—	3280, 3230	1640 (w), 1620
IIIc	410 (4,31); 285 (3,95)	—	—	3290	1620, 1609, 1588
IIId	420 (4,26); 285 (3,95); 260 (4,11)[a,b]	392, 288, 272	455, 284	3341, 3270	1640, 1598
IIIe	470 (3,93); 356 (4,00); 292 (4,23); 256 (4,34)[a]	475, 350, 292 262	505, 362, 296	3332	1640, 1620, 1585
IIIf	405 (4,30); 290 (4,00)[a]; 270 (4,17)	405, 290, 270	—	3372, 3272	1620, 1594
IIIg	420 (4,32); 290 (4,00)[a]; 277 (4,13)	400, 288, 270	445, 280	3338, 3246	1605, 1582
IIIh	315 (3,85); 272 (4,43);	315, 272	—	3164	1620
IIIi	292 (4,02); 273 (4,31)	293, 273	—	3202	1592
Va	427 (4,36); 294 (4,13)	—	—	3300 (Z), 3312 (E)	1604 (Z), 1590 (E)
Vb	432 (4,26); 297 (3,85)	—	—	3252	1634, 1590
VIb	314 (4,11); 218 (4,64)	—	—	3294	1623, 1601
VIc	302; 244[c] (in CH_3OH)	—	305, 250[c]	3198[c]	1609[c]
VId	288 (4,22); 240 (4,20)[a]		296[d]	3225	1594

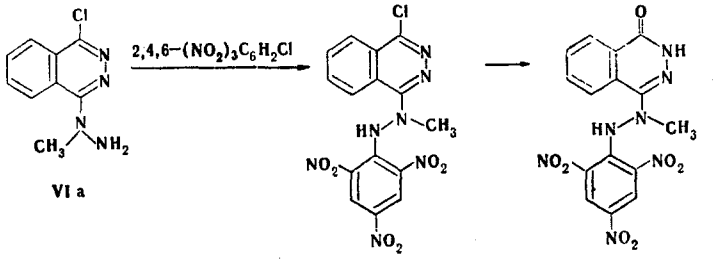
a) Shoulder. b) UV spectrum, λ_{max} (log ε), in C_2H_5OH: 440 (4.28), 280 (4.04), and 210 nm (4.56). c) The spectrum also contains absorption bands of IIIh. d) The sample contains no more than 7% IIIi (shoulder at 273 nm).

The UV spectra of IIIa-g in dioxane (Table 1 and Fig. 1) are also similar to the spectra of starting hydrazones IV [2], but the position of the bands is shifted bathochromically and their intensities are increased. The spectra of hydrazones IIId,g are also similar to the spectra of 2-methyl-4-chlorophthalazone arylhydrazones Va,b but differ markedly from the spectra of arylhydrazine VIb and hydrazine VIa [2], which contain one long-wave absorption band (Table 1 and Fig. 1). Consequently, the products of the reaction of 1-chlorophthalazines with arylhydrazines (IIIa-g) exist in dioxane primarily in the form of phthalazone arylhydrazones.



IV b (Z)-Va,b (E)-Va

Va 4-NO_2; b 2,4,6-$(NO_2)_3$



VI a VI b VII

The UV spectra of IIIh,i in dioxane have the form characteristic for phthalazine systems [1-3] and differ from the spectra of hydrazines VIa,b; this constitutes evidence for their hydrazone structure. An autonomous system of the Ph_2N group (λ_{max} of Ph_2NH 286 nm [12]) appears in the spectrum of hydrazone IIIi at 292 nm because of the rotation about the N-N bond that is characteristic for tetrasubstituted hydrazones [11]. In the case of hydrazone IIIh this is expressed in the considerable increase in the intensity of the short-wave band [λ_{max} of $PhNHCH_3$ [13] and $PhN(CH_3)NH_2$ 244-247 nm (ε 10,000)] as compared with the same band of hydrazone IVa. The transition from a low-polarity solvent ($CHCl_3$) to a polar solvent (DMSO) does not change the form of the UV spectra of hydrazones IIIa-g, whereas the spectra of hydrazones IIIh,i change markedly (Table 1) and become similar to the spectra of hydrazine VIa [2, 5] and arylhydrazine VIb; this indicates conversion of hydrazones IIIa,i to tautomeric phthalazinylhydrazine forms VIc and VId.

Crystalline samples of hydrazone IIIi and hydrazine VId that do not contain tautomeric forms are obtained by recrystallization from, respectively, $CHCl_3$ and DMF (according to the IR and UV spectra of mineral oil suspensions). Complete conversion of hydrazine form VId to hydrazone form IIIi is observed for a freshly prepared solution of hydrazine VId in dioxane after 10-15 min; this makes it possible to establish gradual converson by spectral methods (Fig. 3). It should be noted that the presence of oxygen in the dioxane significantly catalyzes the VId → IIIi conversion. The VId → IIIi conversion proceeds more slowly by a factor of two to three in oxygen-free dioxane (the samples were prepared in a helium atmosphere). The IIIi → VId tautomeric equilibrium was established for both hydrazone IIIi and hydrazine VId in CH_3OH and CH_3CN solutions (IIIi:VId 1:3 in CH_3OH and 1:1 in CH_3CN, according to the UV spectral data).*Equilibrium between the two forms with predominance of the hydrazine form is realized in DMSO and hempa; this is reflected in the UV (IIIa:VId ≈ 1:9 in DMSO) and PMR spectra (Table 2).

In low-polarity solvents ($CHCl_3$, dioxane, isooctane, etc.) IIIh exists exclusively in the hydrazone form, whereas in DMSO, CH_3CN, and CH_3OH it exists as a tautomeric mixture

*Here and subsequently, the UV bands were determined by the basis-line method [14].

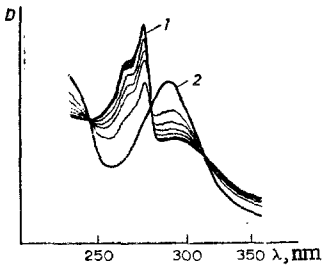


Fig. 3. Change in the UV spectrum of hydrazine VId (2) during its conversion to hydrazone IIIi (1) for a recording interval of 2 min [the form of the spectrum of hydrazine VId (2) was identical to the form of the UV spectrum of VId in DMSO].

TABLE 2. PMR Spectra of Arylhydrazones IIIa,d,g-i and Va and Phthalazinylhydrazine VIb

Compound	Solvent	Chemical shifts, δ, ppm				
		H-8a	H-5—H-7	R^2N b,c	NH	other protons
IIIa	DMSO	8,30	8,14e; 7,14e (4H); (AA'BB')	11,05 (1H)	9,75 (1H)	8,08s (1H, H-4)
IIIa	Hexametapol	8,20	8,14e; 7,17e (4H); (AA'BB')	11,85 (1H)	10,73 (1H)	8,02 s (1H, H-4)
IIId	DMSO	8,10	7,98e; 6,98e (4H); (AA'BB')	11,15 (1H)	9,38 (1H)	—
IIId	Hexametapol	8,35	8,14e; 7,10e (4H); (AA'BB')	12,12 (1H)	10,65 (1H)	—
IIIe	DMSO	8,28	8,04e (1H); 7,52m (2H); 6,77m (1H)	11,81 (1H)	9,78 (1H)	—
IIIe	Hexametapol	8,30	6,87m (1H)	12,88 (1H)	10,08 (1H)	—
IIIg	DMSO	—	8,71s (2H)	11,58 (2H)[d]		—
IIIg	Hexametapol	—	8,75s (2H)	13,25 (2H)[d]		—
IIIh	$CDCl_3$	8,60	6,91 m (5H)	8,80 (1H)	—	3,11 s (3H, CH_3)
IIIh⇌VIc	d_6-DMSO	8,48	6,98 m (5H)	10,03 (1H)		3,29 s (3H, CH_3)
IIIh⇌VIc	d_7-DMF	8,50	6,98 m (5H)	9,95 (1H)		3,19 s (3H, CH_3)
IIIh⇌VIc	Hexametapol	8,68[e]	6,90 m (5H)	11,40[f]	10,84[f]	—
IIIi⇌VId	DMSO	8,50	7,28e; 7,00 m (10H)	12,03[g]	10,60[g]	—
IIIi⇌VId	Hexametapol	8,88 (VId) 8,48 (IIIi)	7,22m; 6,92m (10H)	12,68[g]	11,32[g]	—
Va Z	d_6-DMSO	8,60	8,00e; 7,02e; (AA'BB')	3,55	9,94	—
Va E		8,08	7,80e; 7,06e; (AA'BB')	3,67	9,78	—
Va Z	Hexametapol	8,80	8,12e; 7,25e; (AA'BB')	3,58	10,95	—
Va E		8,22	7,97e; 7,27e; (AA'BB')	3,73	10,78	—
VIb	CH_2Cl_2	8,16	8,76s (2H)	—	10,51 (1H)	3,60s (3H, CH_3)
VIb	d_6-DMSO	—	8,88s (2H)	—	10,68 (1H)	3,55s (3H, CH_3)
VIb	Hexametapol	—	8,93 s (2H)	—	11,20 (1H)	—

a) Multiplet. Multiplet of 5-H—7-H protons at 7.70-8.10 ppm. b) The NH group gives a broad singlet. c) The NCH_3 group of hydrazone Va gives a singlet. d) The signals of the two NH protons merge as a result of proton exchange. e) Broad multiplet (about 30 Hz). f) Overall intensity of one proton unit; IIIh:VIc 4:7. g) Overall intensity of one proton unit; IIIi:VId 1:6 (in DMSO) and 1:10 (in hempa).

(IIIh ⇌ VIc) (IIIh:VIc = 1:10, 1:1, and 1:7, respectively, according to the UV-spectral data). According to the data from the IR and UV spectra of mineral oil suspensions and the UV spectra of crystalline films,* the crystalline samples obtained by recrystallization from $CHCl_3$ or DMSO are the same tautomeric mixture (IIIh:VIc = 1:15). The rate of the IIIh ⇌ VIc interconversions is evidently considerably higher in d_6-DMSO and d_7-DMF than for the IIIi ⇌ VId system, and an averaged PMR spectrum (Table 2) is observed even at −80°C (in d_7-DMF). However, the rate of the exchange processes is lower in hempa, and the tautomers show up individually in the PMR spectrum.

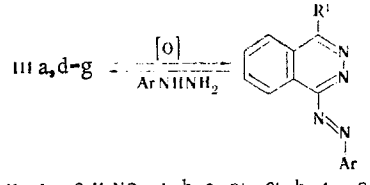
The dependence of the position of the signal of the NH proton on the polarity of the solvent in the PMR spectra (Table 2) indicates the absence of an intramolecular hydrogen bond (IHB) in 4-nitrophenylhydrazones IIIa,d and the realization of an IHB in 2-nitrophenylhydrazone IIIe and hydrazine VIb between the nitro group and the proton of the adjacent NH group.

It is known [1-3] that the signal of the 8-H proton in the PMR spectra of phthalazones and their imines and hydrazones undergoes a weak-field shift relative to the multiplet of the 5-H–7-H protons because of the anisotropic effect of the exocyclic multiple bond and differs for the Z and E isomers of the hydrazones because of the nonequivalence of the spatial orientation of the amino group of the hydrazone fragment attached to them. The similarity in the forms of the signals and the chemical shifts of the protons of the phthalazone ring, including the 8-H proton, in the spectra of arylhydrazones IIIa-i [Fig. 2, spectrum c; compare this spectrum with the spectrum of hydrazine VIb in Fig. 2 (spectrum a)], the E forms of hydrazones IVa,b [2], ylidenehydrazones [1], and azines of 2-H-phthalazones [3] makes it possible to conclude that arylhydrazones IIIa-i exist in the form of the E isomer.

It is apparent from the PMR spectra [Table 2 and Fig. 2 (spectrum b)] that 2-methyl-4-chlorophthalazone 4-nitrophenylhydrazone (Va), after purification by recrystallization from DMF, exists as a mixture of two geometrical isomers (Z:E = 3:2) in d_6-DMSO and hempa. Crystalline hydrazone Va is also a mixture of the Z and E forms, as evidenced by the IR spectrum of the compound in mineral oil. Almost all of the absorption bands are doublets (we assigned the second peak in the form of a shoulder at 3312, 1590 cm^{-1}, etc. to the E isomer). We were unable to separate the isomers of hydrazone Va with a column filled with Al_2O_3, although their ratio in the isolated samples did change somewhat. Hydrazone Va, which was isolated from the reaction medium and purified by repeated washing with CH_3OH, is, according to the PMR spectral data, also a mixture of the Z and E forms in a ratio of 3:1. In a control experiment repeated washing of a mixture of the isomers (3:2) with CH_3OH did not change the isomer ratio. The percentage of the E isomer increases as a result of crystallization from DMF (the coalescence temperature is ≈130°C).

We were unable to record the PMR spectrum of hydrazone Vb because of its low solubility; however, on the basis of its IR spectrum it may be concluded that a single form (evidently the Z form [1-3]) is realized in the crystals.

Hydrazine VIb readily undergoes saponification (in 3-5 days) to derivative VII in solution in 96% DMSO at room temperature. The absorption bands at 1670 and 3177 cm^{-1} (C=O and NH) in the IR spectrum, the position of the NH signal (12.32 ppm), which is characteristic for phthalazone systems [1, 2], the weak-field shift of the 5-H signal (8.18 ppm), and the UV spectrum constitute evidence that VII exists primarily in the oxo form in solution and in the crystalline state. Arylhydrazones IIIa-g and Va,b remain unchanged even after months under similar conditions. This difference between hydrazones III and V and hydrazine VIb also confirms the structure of III.



VIII a R^1 = H, Ar = $C_6H_4NO_2$-4; b-e R^1 = Cl; b Ar = $C_6H_4NO_2$-4; c $C_6H_4NO_2$-2; d $C_6H_4(NO_2)_2$-2,4; e $C_6H_2(NO_2)_3$-2,4,6

*Obtained by the method in [5].

TABLE 3. Characteristics of Arylhydrazones IIIa-i and Va,b, Hydrazine VIb, and Arylazophthalazines VIIIa-e

Compound	mp, °C[a]	Crystallization solvent	Found, %				Empirical formula	Calc., %				Yield, %
			C	H	Cl	N		C	H	Cl	N	
IIIa	228—230	DMF	60,0	3,9	—	24,8	$C_{14}H_{11}N_5O_2$	59,8	3,9	—	24,9	90
IIIb	234—235	Dioxane	60,0	4,0	—	24,9	$C_{14}H_{11}N_5O_2$	59,8	3,9	—	24,9	80
IIIc	216—219	Dioxane	51,3	3,1	—	25,9	$C_{14}H_{10}N_6O_4$	51,5	3,1	—	25,8	85
IIId	232—234	Dioxane	53,3	3,1	11,3	22,2	$C_{14}H_{10}ClN_5O_2$	53,2	3,2	11,2	22,2	90
IIIe	215—217	C_2H_5OH	53,3	3,2	11,3	22,5	$C_{14}H_{10}ClN_5O_2$	53,2	3,2	11,2	22,2	80
IIIf	226—227	DMF	46,5	2,4	9,9	23,2	$C_{14}H_9ClN_6O_4$	46,6	2,5	9,9	23,3	95
IIIg	206	DMF C_2H_5OH[b]	41,6	2,0	8,8	24,3	$C_{14}H_8ClN_7O_6$	41,4	2,0	8,8	24,2	91
IIIh	195—196	$CHCl_3$	63,2	4,5	12,6	20,0	$C_{15}H_{13}ClN_4$	63,3	4,6	12,5	19,7	60
IIIi	196—197	C_2H_5OH	69,2	4,4	10,2	16,2	$C_{20}H_{15}ClN_4$	69,3	4,3	10,3	16,2	85
Va	163—164	DMF	54,5	3,6	10,7	21,0	$C_{15}H_{12}ClN_5O_2$	54,6	3,6	10,8	21,2	53
Vb	204—205	Dioxane C_2H_5OH[b]	43,1	2,5	8,4	23,4	$C_{15}H_{10}ClN_7O_6$	42,9	2,4	8,5	23,4	20
VIb	195	Dioxane	42,8	2,4	8,5	23,6	$C_{15}H_{10}ClN_7O_6$	42,9	2,4	8,5	23,4	49
VIIIa	230—231	DMF	60,0	3,2	—	25,1	$C_{14}H_9N_5O_2$	60,2	3,2	—	25,1	85/80c
VIIIb	234—236	DMF	53,6	2,5	11,4	22,4	$C_{14}H_8ClN_5O_2$	53,6	2,6	11,3	22,3	80/90c
VIIIc	205—206	THF (60—70%)	53,5	2,6	11,2	22,3	$C_{14}H_8ClN_5O_2$	53,6	2,6	11,3	22,3	90/80c
VIIId	220—221	Dioxane (80%)	46,9	2,0	9,7	23,4	$C_{14}H_7ClN_6O_4$	46,9	2,0	9,9	23,4	70/75c
VIIIe	188	Dioxane	41,8	1,5	8,9	24,3	$C_{14}H_6ClN_7O_6$	41,6	1,5	8,8	24,3	80/85 c

a) With decomposition. b) A fourfold volume of hot ethanol was added to a hot solution of the compound in DMF (in dioxane), and the mixture was cooled slowly. c) The yield of product in the case of yellow HgO is indicated in the numerator, and the yield in the case of HNO_3 solutions is indicated in the denominator.

Hydrazones IIIa,d-g are readily oxidized by yellow HgO or HNO_3 to the corresponding 1-(arylazo)phthalazines VIIIa-e, the structures of which are confirmed by the IR (absence of NH and C=N absorption bands) and UV spectra, which have the intense absorption at 262-292 nm that is characteristic for other phthalazine derivatives [2], as well as absorption at 325-335 nm in the form of a shoulder on the principal band (evidently due to the development of a system of conjugation involving the phthalazine ring, the azo group, and the aryl ring [15]). The long-wave absorption of weak intensity [λ_{max} 440-475 nm (ε 1000)] corresponds to $\pi-\pi^*$ transitions [12].

The chlorine atom in VIIIb-e should be replaced under the influence of nucleophilic reagents [5, 7]. However, reduction products — arylhydrazones III — were unexpectedly isolated in the reaction of VIIIb-e with arylhydrazines.

EXPERIMENTAL

The conditions under which the spectral measurements were made and monitoring of the purity and other physicochemical measurements were accomplished are presented in [5]. The purification of the dioxane and the removal of oxygen were carried out by the method in [16] with subsequent rectification with a column (17 theoretical plates) in a stream of helium.

Nitrophenylhydrazones IIIa-f. A 5-mmole sample of 1-chloro- (Ia, solution in 10 ml of dioxane) or 1,4-dichlorophthalazine (Ib) was added to a hot solution of 10 mmole of the appropriate hydrazine II in 20-25 ml of dioxane, and the mixture was refluxed for 40 min (separation of the precipitated yellow crystals from the hot solution prior to the addition gave the hydrochlorides of IIIa,c,d,f), after which 40 ml of water was added, and the mixture was refluxed for another 5 min. It was then cooled, and the resulting precipitate was removed by filtration and washed with hot water to give cherry-red crystals of hydrazones IIIa-c,d,f and black crystals of hydrazone IIIe (Tables 1-3).

4-Chlorophthalazone 2,4-Dinitrophenylhydrazone (IIIf). A 0.5-g (2.5 mmole) sample of 2,4-dinitrochlorobenzene was sprinkled into a solution of 0.97 g (5 mmole) of hydrazone IVa in a mixture of 50 ml of DMF and ethanol (1:5), and the mixture was refluxed for 30 min. It was then cooled at 10°C for 8 h, after which the precipitate was removed by filtration and washed twice with alcohol to give 1.62 g (90%) of hydrazone IIIf as a cherry-red crystalline powder with mp 224-225°C (dec.). No melting-point depression was observed for a mixture of this product with the product of the reaction of phthalazine Ib with hydrazine IIc.

4-Chlorophthalazone 2,4,6-Trinitrophenylhydrazone (IIIg). A 1.24-g (5 mmole) sample of picryl chloride was sprinkled into a solution of 1.95 g (10 mmole) of hydrazone IVa in 30 ml of absolute dioxane, and the mixture was refluxed for 5 min. The hot mixture was filtered, and the solid material was washed two to three times with cold dioxane. Water (250 ml) was added to the mother liquor, and the resulting precipitate was removed by filtration to give shiny cherry-red crystals of hydrazone IIIg.

4-Chlorophthalazone N-Methyl-N-phenylhydrazone (IIIh). A 3.1-ml (25 mmole) sample of 1-methyl-1-phenylhydrazine was added dropwise to a hot solution of 2.5 g (12.5 mmole) of 1,4-dichlorophthalazine in 35 ml of absolute benzene, and the mixture was refluxed for 3.5 h. The solvent was then removed in vacuo to give a white (with a yellow tint) crystalline powder, which was identified as a mixture of the tautomeric hydrazone IIIh and hydrazine VIc.

4-Chlorophthalazone Diphenylhydrazone (IIIi). A 2-g (50 mmole) sample of NaOH was added to 11 g (50 mmole) of 1,1-diphenylhydrazine hydrochloride in 100 ml of ethanol, and the mixture was refluxed for 5-10 min. A 4.97-g (25 mmole) sample of 1,4-dichlorophthalazine was added to the resulting mixture, and refluxing was continued for 20 min. The mixture was then cooled and treated with 150 ml of water, and the copious precipitate was removed by filtration to give hydrazone IIIi as a white (with a greenish tint) crystalline powder.

2-Methyl-4-chlorophthalazone 4-Nitrophenylhydrazone (Va). A solution of 1,4-dichloro-2-methylphthalazinium methylsulfate (from 5 g (25 mmole) of phthalazine Ib, 5 ml of dimethyl sulfate, and 10 ml of chlorobenzene [2]) was added dropwise with vigorous stirring in the course of 5 min at 20°C to a solution of 15.3 g (100 mmole) of 4-nitrophenylhydrazine in a mixture of 60 ml of absolute dioxane and 30 ml of DMSO, after which stirring was continued for another 30 min. Water (350 ml) was added, and the mixture was stirred for 10 min. The resulting precipitate was removed by filtration and washed three times with methanol to give dark-cherry-red needles of hydrazone Va.

2-Methyl-4-chlorophthalazone 2,4,6-Trinitrophenylhydrazone (Vb). A 1.23-g (5 mmole) sample of picryl chloride was springkled into a hot solution of 2.06 g (10 mmole) of hydrazone IVb in 15 ml of absolute dioxane, and the mixture was refluxed for 15 min. The solvent was removed by vacuum evaporation to dryness, and the residue was extracted with chloroform. The solvent was removed from the extract to give shiny black crystals of hydrazone Vb.

1-Methyl-1-(4-chloro-1-phthalazinyl)-2-(2,4,6-trinitrophenyl)hydrazine (VIb). A 1.24-g (5 mmole) sample of picryl chloride was sprinkled into a solution of 2.08 g (10 mmole) of 1-methyl-1-(4-chloro-1-phthalazinyl)hydrazine in 30 ml of absolute dioxane, and the mixture was stirred at 20°C for 30 min. The precipitated hydrochloride of the starting hydrazine was removed by filtration and washed twice with dioxane, and the solvent was removed from the filtrate by vacuum evaporation to give yellow crystals of hydrazine VIb.

1-Methyl-1-(4-phthalazon-1-yl)-2-(2,4,6-trinitrophenyl)hydrazine (VII). A solution of 1.04 g (2.5 mmole) of hydrazine VIb in 40 ml of 95% DMSO was maintained at 20°C for 7 days, after which 150 ml of methanol was added, and the mixture was held at 0°C for 5 h. The precipitate was removed by filtration and washed three times with methanol to give 0.93 g (93%) of hydrazine VII as yellow crystals (from dioxane) with mp 244-245°C. UV spectrum, λ_{max} (log ε), dioxane: 313 (4.20) and 262 nm (4.20). IR spectrum: 1670 (C=O), 3177 (N^3-H), and 3300 cm^{-1} (NH). PMR spectrum, δ (d_6-DMSO): 7.85 m (3H, 5-H—7-H), 8.18 m (1H, 8-H), 8.83 s (2H, H_{ar}), 10.15 Br s (1H, NH), 12.32 br s (1H, N^3-H), and 3.52 s (3H, NCH_3) ppm. Found, %: C 44.9; H 2.7; N 24.4. $C_{15}H_{11}N_7O_7$. Calculated, %: C 44.8; H 2.7; N 24.6.

1-(4-Nitrophenylazo)phthalazine (VIIIa), 1-(4-Nitrophenylazo)- (VIIIb), 1-(2-Nitrophenylazo)- (VIIIc), 1-(2,4-Dinitrophenylazo)- (VIIId), and 1-(2,4,6-Trinitrophenylazo)-4-chlorophthalazine (VIIIe). A) A 32-g (150 mmole) sample of yellow mercuric oxide was sprinkled into a solution of 10 mmole of the appropriate arylhydrazone III in 200 ml of THF, and the mixture was stirred vigorously at 15-25°C for 8 h. The sediment was removed by filtration and washed two to three times with THF, and the solvent was removed by vacuum distillation to give cherry-red needles of phthalazine VIIIa, light-cherry-red powdered VIIIc,d, and red crystalline powdered phthalazine VIIIe. UV spectra in dioxane, λ_{max} (log ε): VIIIa 422* (2.78), 325* (4.13), 292 (4.28), and 214 (4.60); VIIIb 460* (2.93), 330* (4.14), 294 (4.28), and 215 (4.58); VIIIc 243* (4.36), 450* (2.99), 290 (4.11), and 215 (4.57); VIIId 455* (2.90), 332* (4.02), 280 (4.27), and 216 (4.63); VIIIe 475* (2.70), 335* (3.90), 262 (4.30), and 220 nm (4.62).

*Shoulder.

B) A suspension of 5 mmole of the appropriate arylhydrazone III in 25 ml of 28% HNO_3 (14% HNO_3 for hydrazone IIId) was triturated thoroughly in a porcelain mortar for 10 min (25 min for hydrazone IIId), after which 100 ml of water was added, and the mixture was filtered. The solid product was washed thoroughly with water to give the corresponding arylazophthalazines VIIIa-e, which were identical to the VIIIa-e obtained by method A.

Reaction of Phthalazine VIIIb with 4-Nitrophenylhydrazine. A 1.52-g (5 mmole) sample of azo compound VIIIb was sprinkled into a hot solution of 1.53 g (10 mmole) of 4-nitrophenylhydrazine (IIa) in 90 ml of isopropyl alcohol, and the mixture was refluxed for 30 min. It was then cooled to 50°C, and the precipitate was removed by filtration to give 1.20 g (76%) of a cherry-red crystalline substance that was identical to hydrazone IIId.

Reaction of Phthalazine VIIId with 4-Nitro- (IIa) and 2,4-Dinitrophenylhydrazine (IIc). A 1.78-g (5 mmole) sample of azo compound VIIId was sprinkled into a hot solution of 1.53 g (10 mmole) of hydrazine IIa in 80 ml of ethanol [or 1.66 g (10 mmole) of hydrazine IIc in 200 ml of ethanol], and the mixture was refluxed for 30 min (80 min in the case of hydrazine IIc). The resulting precipitate was removed from the hot mixture by filtration to give 1.50 g (84%) [1.30 g (73%) in the case of hydrazine IIc] of a product with mp 226-227°C (dec., from DMF), which was identical to arylhydrazone IIIf.

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