

CYCLIZATION REACTIONS OF SOME *o*-ACYLPHENYLHYDRAZONES*Jan SLOUKA^a, Vojtěch BEKÁREK^a and Antonín LYČKA^b^a Department of Analytical and Organic Chemistry, Palacký University, 771 46 Olomouc and^b Research Institute of Organic Syntheses, 532 16 Pardubice - Rybitví

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The hydrazones *Ia–Id* and *Ila–Ild* have been prepared by azo coupling of ethyl cyanacetylcarbamate and cyanacetamide, respectively, with diazotized *o*-aminoacetophenone, *o*-aminobenzophenone, 2-(2-aminobenzoyl)benzoic acid and 1-amino-9,10-anthraquinone. The hydrazones *Ia–Id* have been alkaline or thermally cyclized to 2-aryl-4,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitriles *IIla–IIId*. On boiling in strongly acidic medium the hydrazones *I* and *II* are cyclized to the corresponding 3-substituted indazoles *Va–Vc* and 2,6-dihydronaphtho-[1,2,3-*c,d*]indazol-6-one (*Vd*). Three hours boiling in 20% hydrochloric acid does not affect the 1,2,4-triazine cycle of nitriles *IIla–IIId*, the nitrile groups being only hydrolyzed to give the corresponding carboxylic acids *IVa–IVd*. On the contrary, boiling in aqueous pyridine causes splitting of the 1,2,4-triazine cycle and formation of arylhydrazonocyanacetamides *Ila–Ild*. IR and NMR spectroscopy has been used to study the possibility of simultaneous hydrogen bond to the both carbonyl groups in hydrazones *I* and *II*.

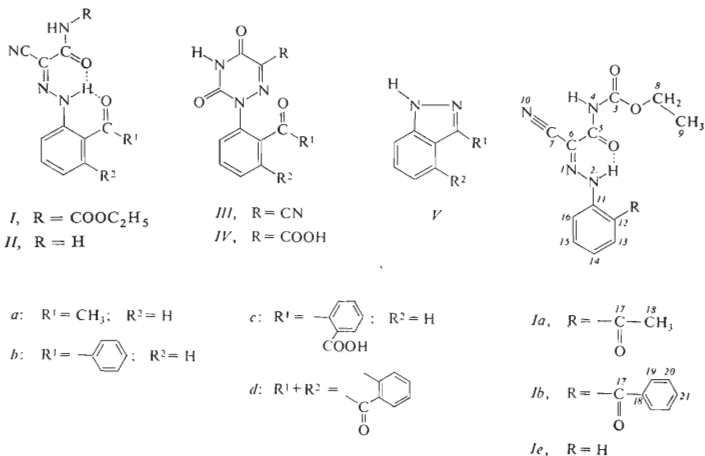
Within the framework of studies of cyclization reactions of hydrazones, in this communication we have focused attention to some arylhydrazones substituted by acyl group at the vicinal position in order to evaluate influence of this group on course of cyclization reactions.

Diazotation of *o*-aminoacetophenone, *o*-aminobenzophenone, 2-(2-aminobenzoyl)benzoic acid and 1-amino-9,10-anthraquinone and coupling of the obtained diazonium salts with ethyl cyanacetylcarbamate in aqueous sodium acetate medium gave good yields of the corresponding arylhydrazonocyanacetylcarbamates *Ia–Id*. Similarly the same diazonium salts were coupled with cyanacetamide to give the respective arylhydrazonocyanacetamides *Ila–Ild*. These coupling reactions were substantially slower due to lower reactivity of cyanacetamide as compared with ethyl cyanacetylcarbamate. Satisfactory yields of the hydrazones *Ia* and *Ila* indicate that intramolecular couplings of the respective diazonium salts to 4-hydroxycinnoline are negligible.

Alkaline cyclization in aqueous sodium carbonate solution transforms the hydrazones *Ia–Ic* to the corresponding 2-(*o*-acylphenyl)-3,5-dioxo-2,3,4,5-tetrahydro-

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-1,2,4-triazine-6-carbonitriles *IIIa–IIIc*. This method was inefficient with the hydrazone *Id* due to its low solubility. However, the hydrazone *Id* could be easily cyclized to 2-(9,10-anthraquinon-1-yl)-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitrile (*IIIId*) by boiling in nitrobenzene, *i.e.* thermally. The nitrile *IIIb* was prepared besides alkaline cyclization also by thermal cyclization of hydrazone *Ib* (boiling in decaline). On boiling in hydrochloric acid all the hydrazone *I* and *II* undergo hydrolytic splitting and intramolecular cyclization to give the respective 3-substituted indazoles *Va–Vc* and 2,6-dihydronaphtho[1,2-*c,d*]indazol-6-one (*Vd*).



Furthermore we investigated stability of the 1,2,4-triazine cycle of nitriles *IIIa* to *IIIId* to hydrolytic splitting. In accordance with previous findings^{1–3} it was found that electron-acceptor –M effect of the acyl groups causes ring splitting during boiling of these nitriles in aqueous pyridine, the respective arylhydrazonocyanacetamides *IIa–IIId* being formed which are identical with the compounds prepared by coupling. The splitting of nitrile *IIIc* gave pyridinium salt of hydrazone *IIc* giving the hydrazone on acidification. Three hours boiling in 20% hydrochloric acid causes an only negligible ring opening of nitriles *IIIa–IIIId*, so that the corresponding 2-aryl-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carboxylic acids *IVa–IVd* were obtained in good yields, traces of the respective indazoles *V* being the only side products. Prolongation of reaction time decreases yields of the acids *IV* due to recyclization of the indazoles *V* formed.

In previous communications^{4,5} it was proved that azo coupling of diazonium salts with ethyl cyanacetylcarbamate only gave that one of the geometrical isomers of the respective hydrazone which was stabilized by intramolecular hydrogen bond between the hydrazone H—N group and carbonyl group. The hydrazones *Ia*–*Id* studied in the present work, however, have still other carbonyl group in a sterically favourable position, which evokes a question about simultaneous existence of hydrogen bonds between the H—N group and oxygen atoms of the both carbonyl groups. The hydrazones *Ia* and *Ib* were investigated by means of NMR and IR spectroscopy. Using Na¹⁵NO₂, we also prepared, by the above-mentioned procedure, the hydrazone *Ib* with ¹⁵N isotope at 1 position.

Table III gives ¹³C NMR spectra of hydrazones *Ia*, *Ib* and that of the ethyl phenyl hydrazonecyanacetylcarbamate (*Ie*) prepared earlier^{6,7} along with assignment of individual signals. The assignment of ¹³C NMR signals was carried out on the basis of the proton-decoupled and proton-coupled spectra and with the use of model substances. The lowest-field signal belongs to C=O group, the chemical shift 111.59 ppm corresponding to CN group. Comparison with the published data⁸ allows to differentiate the atoms C(3) and C(5) in the hydrazone *Ie*. Furthermore, ¹⁵N chemical shifts (from natural abundance of the ¹⁵N isotope) were measured with the compound *Ie* without and with addition of Cr(acac)₃ (about 10 mg/ml): $\delta_{N(2)} =$

TABLE I

¹³C chemical shifts of hydrazones *Ia*, *Ib*, and *Ie*

$\delta^{13}\text{C}$	<i>Ie</i> ^a	<i>Ia</i> ^{a,b,c}	<i>Ia</i> ^{d,e}	<i>Ib</i> ^{a,f}
C(3)	150.95	150.46	150.13	150.64
C(5)	160.21	158.54	157.09	158.89
C(6)	107.00	109.80	109.29	110.21
C(7)	111.09	111.32	111.69	110.47
C(8)	61.53	61.42	62.78	61.71
C(9)	14.36	13.92	14.23	14.27
C(11)	141.78	141.86	142.46	141.80
C(12)	116.88	120.63	120.94	122.97
C(13)	129.16	131.32	132.05	132.74
C(14)	124.97	123.72	124.21	124.14
C(15)	129.16	134.78	135.33	134.02
C(16)	116.88	116.41	115.49	118.11

^a In hexadeuteriodimethyl sulphoxide; ^b at 80°C; ^c $\delta\text{CO} = 202.88$, $\delta\text{CH}_3 = 27.78$; ^d in deuteriochloroform; ^e $\delta\text{CO} = 202.01$, $\delta\text{CH}_3 = 27.86$; ^f $\delta\text{C}(17) = 198.14$, $\delta\text{C}(18) = 137.59$, $\delta\text{C}(19) = 129.52$, $\delta\text{C}(20) = 128.64$, $\delta\text{C}(21) = 132.91$.

$= -206.9$, -207.6 ; $\delta_{N(1)} = -14.3$, -15.1 ; $\delta_{N(10)} = -99.7$; $\delta_{N(4)} = -251.5$, -252.5 . (The ^{15}N chemical shifts relate to external neat nitromethane (25% ^{15}N), negative values denoting up-field shifts.) The assignment was carried out by comparison with literature data⁹. In case of compounds *Ia* and *Ib* the chemical shifts for the atoms C(11)—C(16) were assigned on the basis of comparison of the experimental values with those calculated from ^{13}C substitution chemical shifts¹⁰, and the assignment was checked with respect to the proton-coupled spectrum. The ^{13}C chemical shifts of hydrazone *Ia* measured in hexadeuteriodimethyl sulphoxide are practically identical with those obtained in deuteriochloroform solution. The atoms C(17)—C(21) in hydrazone *Ib* were assigned according to ref.¹¹. In hydrazone *Ib* 1- ^{15}N we found the ^{15}N chemical shift $\delta_{N(1)} = -14.9$ ppm.

The obtained spectral data do not allow definitive conclusion to be made about simultaneous participation of the carbonyl groups C(5) and C(17) in formation of intramolecular hydrogen bond with H atom of hydrazone group. A certain participation of the two carbonyl groups can be inferred from the ^{13}C chemical shift of C(5) atom in the series *Ie*—*Ib*—*Ia*. Introduction of acetyl group (hydrazone *Ia*) and benzoyl group (hydrazone *Ib*) in 12 position of hydrazone *Ie* causes lowering of chemical shift of this carbonyl atom C(5). This lowering could be connected with the increased electron density at the C(5) atom due to its decreased participation as an electron donor in this intramolecular hydrogen bond because of partial formation of hydrogen bond between the H—N group and carbonyl group C(17). Furthermore, the co-participation of the both carbonyl groups as electron donors in hydrogen bond with H—N group is supported by the fact that the C(5) chemical shift is lower for the stronger electron-donor, acetyl group (in *Ia*), than for benzoyl group (in *Ib*) and by decrease of chemical shifts (increase of electron densities) of the C(3) carbonyl atom in the series *Ie*—*Ib*—*Ia*. If the hydrazones *I* existed in the form of the second geometrical isomer, then the decrease in chemical shift of the C(5) atom would probably be more distinct.

The results of IR spectroscopy of hydrazones *I* involve an interesting marked difference between bands of valence vibration of $\text{C}\equiv\text{N}$ bond in solid state and in solution. Thus with the derivative *Ib* in solid state this vibration manifests itself by two bands of medium intensity at 2213 and 2188 cm^{-1} , whereas in dichloromethane solution the compound gives only one band at 2218 cm^{-1} . This fact indicates a marked intermolecular interaction of nitrile group in solid state. With hydrazone *Ib* substitution of ^{15}N isotope for ^{14}N atom at 1 position caused a shift of the absorption band at 1527 cm^{-1} (in CH_2Cl_2) by 6 cm^{-1} towards lower wave numbers, which made it possible to assign the mentioned band of this and other hydrazones to $\text{C}=\text{N}$ bond. Similar shift of the band at 1216 cm^{-1} by 6 cm^{-1} to lower wave numbers allows to assign this band most probably to $\text{N}-\text{N}$ bond.

3-Phenylindazole (*Vb*) is known to exist in two modifications differing in their melting points^{12,13}. We studied the two modifications by IR spectroscopy to decide

if they are crystal modifications or 1*H*- and 2*H*-tautomers. Whereas the spectra of the two modifications measured in solid state show significant differences in positions of some bands, the IR spectra of solutions in carbon disulfide are identical. Comparison of IR spectra of isotopomers *Vb* 2-¹⁴N and *Vb* 2-¹⁵N (prepared by the above-mentioned cyclization of hydrazone *Ib* 1-¹⁵N) reveals the existence of 1*H*-tautomer, the position of intensive absorption band of N—H valence vibration at 3 453 cm⁻¹ (in CH₂Cl₂) being almost unaffected by the said isotope substitution (whereas in the 2*H*-tautomer it would have to cause a marked shift). Dependence of position of the more intensive absorption band of N—H valence vibration on medium is obviously more distinct than that of pyrrole¹⁴ and is given in Table IV.

EXPERIMENTAL

The melting points were determined with a Boetius apparatus and are uncorrected. The IR spectra were measured with an IR-75 spectrometer (Zeiss, Jena) either in solutions (CH₂Cl₂ or CS₂) or in KBr disc. The NMR spectra were measured with a 100 MHz apparatus FX-100 (JEOL) under the conditions described in ref.⁹.

Ethyl 2-Acetylphenylhydrazonocyanacetylcarbamate (*Ia*)

Solution of 2.75 g (20.3 mmol) *o*-aminoacetophenone¹⁵ in a mixture of 15 ml 37% HCl and 45 ml water was cooled to 0–3°C, treated with crushed ice and diazotized with solution of 1.38 g (20.0 mmol) NaNO₂ in 8 ml ice water. The solution was left to stand 30 min at 0–3°C and then added with stirring and cooling to a mixture prepared by dissolving 4.20 g (26.9 mmol) ethyl cyanacetylcarbamate and 50 g sodium acetate in 900 ml warm water, cooling to 0–3°C and finally by addition of crushed ice. After 24 h the separated solid was collected by suction, washed with water, and dried at room temperature. Yield 5.52 g (91.3%). After recrystallization from ethanol m.p. 179–181°C. For C₁₄H₁₄N₄O₄ (302.3) calculated: 55.62% C, 4.67% H, 18.54% N; found: 55.53% C, 4.41% H, 18.51% N. IR spectrum (CH₂Cl₂, cm⁻¹): 497 w, 515 m, 590 m, 625 m,

TABLE II
Solvent effect on valence vibration of N—H bond in derivative *Vb*

Solvent	N—H, cm ⁻¹	Solvent	N—H, cm ⁻¹
Hexane	3 487	Dichloromethane	3 453
Cyclohexane	3 481	1,2-Dichloroethane	3 439
Tetrachloromethane	3 478	Dibromomethane	3 441
Tetrachloroethylene	3 473	Diiodomethane	3 426
Carbon disulphide	3 461		

843 w, 918 m, 930 m, 963 m, 991 m, 1 026 s, 1 035 sh, 1 073 w, 1 096 m, 1 133 m, 1 165 s, 1 185 s, 1 294 s, 1 314 m, 1 331 m, 1 365 m, 1 375 m, 1 457 s, 1 491 s, 1 525 s, 1 589 s, 1 609 m, 1 660 s, 1 703 w, 1 721 s, 1 740 m, 1 786 s, 2 217 m, 3 406 m.

Ethyl 2-Benzoylphenylhydrazonocyanacetylcarbamate (*Ib*)

Solution of 3.85 g (20.0 mmol) *o*-aminobenzophenone¹⁶ in 50 ml acetic acid, 200 ml water and 40 ml 37% HCl was cooled to 0–3°C, treated with crushed ice and diazotized with solution of 1.38 g (20.0 mmol) NaNO₂ in 20 ml ice water. The mixture was left to stand 20 min in ice bath with intermittent stirring and then added portionwise with stirring to a mixture prepared by dissolving 4.20 g (26.9 mmol) ethyl cyanacetylcarbamate and 120 g sodium acetate in 1 000 ml water and cooling by addition of crushed ice. The mixture was left to stand 24 h with intermittent stirring at 0–5°C; the yellow voluminous precipitate was collected by suction, washed with water and dried. Yield 6.72 g (92.3%); after recrystallization from ethanol m.p. 175–177°C. For C₁₉H₁₆N₄O₄ (364.3) calculated: 62.63% C, 4.43% H, 15.38% N; found: 62.64% C, 4.45% H, 15.36% N. IR spectrum (CH₂Cl₂, cm⁻¹): 445 w, 522 m, 478 m, 601 m, 646 s, 809 m, 926 s, 944 m, 1 003 w, 1 027 s, 1 041 sh, 1 079 w, 1 096 w, 1 133 w, 1 155 m, 1 168 m, 1 184 s, 1 216 m, 1 305 m, 1 323 m, 1 374 m, 1 398 w, 1 448 m, 1 455 m, 1 494 s, 1 588 m, 1 599 w, 1 607 m, 1 637 s, 1 703 w, 1 721 s, 1 739 m, 1 785 s, 2 217 m, 3 406 m.

Hydrazone *Ib* 1-¹⁵N was prepared in the same way with Na¹⁵NO₂; its IR spectrum (in CH₂.Cl₂) shows the following band shifts relative to *Ib* 1-¹⁴N (cm⁻¹): 1 521 s and 1 210 m instead of 1 526 s and 1 216 m, respectively.

Ethyl 2-(2-Carboxybenzoyl)phenylhydrazonocyanacetylcarbamate (*Ic*)

Mixture of 710 mg (3.18 mmol) 1,11-dihydro-6*H*-dibenzo[*b,e*]azepin-6,11-dione¹⁷, 300 mg NaOH and 15 ml water was refluxed until dissolution. The solution was cooled to 0–3°C and treated with 207 mg (3.0 mmol) NaNO₂. This solution was then added portionwise with stirring and cooling in a mixture of 20 ml ice water, 6.5 ml 37% HCl and 10 g crushed ice. The mixture was stirred in ice bath 30 min and then added portionwise with stirring to a mixture obtained by dissolving 600 mg (3.84 mmol) ethyl cyanacetylcarbamate and 7.50 g sodium acetate in 150 ml water and cooling to 0–3°C by addition of crushed ice. The mixture was left to stand at 0–3°C 24 h, the precipitate was collected by suction and washed with water. After drying at room temperature yield 1.04 g dihydrate (76.9%), m.p. 139–141°C. For C₂₀H₂₀N₄O₈ (444.4) calculated: 54.06% C, 4.54% H, 12.61% N; found: 54.11% C, 4.42% H, 12.46% N. IR spectrum (KBr, cm⁻¹): 524 w, 550 w, 586 w, 601 w, 642 m, 661 m, 692 w, 718 m, 753 m, 773 w, 775 m, 892 w, 927 m, 939 m, 1 018 s, 1 082 m, 1 093 m, 1 128 sh, 1 159 m, 1 196 s, 1 242 m, 1 286 m, 1 318 w, 1 371 m, 1 394 w, 1 352 m, 1 493 s, 1 523 s, 1 585 m, 1 605 m, 1 639 s, 1 699 s, 1 741 s, 2 215 m, 2 330 m, 2 986 w, 3 083 w. Drying at 100° caused a mass decrease corresponding to loss of 2 water molecules. The anhydrous substance, m.p. 207–209°C, was also obtained by recrystallization of the dihydrate from ethanol. For C₂₀H₁₆N₄O₆ (408.4) calculated: 58.82% C, 3.95% H, 13.72% N; found: 58.59% C, 3.77% H, 14.00% N.

Ethyl 9,10-Anthaquinon-1-ylhydrazonocyanacetylcarbamate (*Id*)

Powdered NaNO₂ (850 mg, 12.3 mmol) was added portionwise to 13 ml conc. H₂SO₄ with stirring and keeping the temperature below 10°C. Thereafter the reaction mixture was stirred in ice bath 15 min, heated to room temperature and, after 10 min, to 70°C and again cooled to 12–15°C. The nitrosylsulphuric acid prepared in this way was treated with 2.24 g (10.0 mmol)

1-amino-9,10-anthraquinone added portionwise with stirring and cooling at 12–15°C. Then the mixture was stirred at 12–15°C for 4 h, the temperature was raised to 35°C and decreased again to 10°C in ice bath. The prepared diazonium salt was added portionwise with stirring to a mixture prepared by dissolving 2.10 g (13.45 mmol) ethyl cyanacetylcarbamate and 70 g sodium acetate in 600 ml water, cooling to 0–3°C and addition of crushed ice. The mixture was stirred in ice bath 20 min and left to stand at 0–3°C 24 h. The separated solid was collected by suction, washed with water and dried at room temperature. Yield 3.70 g (94.8%). After repeated crystallization from chloroform m.p. 243–245°C, resolidification at 254°C. For $C_{20}H_{14}N_4O_5$ (390.3) calculated: 61.54% C, 3.62% H, 14.35% N; found: 61.36% C, 3.63% H, 14.13% N. IR spectrum (KBr, cm^{-1}): 480 w, 545 m, 585 m, 611 m, 618 sh, 630 sh, 664 w, 700 sh, 715 s, 742 m, 760 w, 776 m, 814 m, 838 m, 934 s, 1 002 m, 1 027 s, 1 040 w, 1 077 w, 1 100 w, 1 139 m, 1 172 m, 1 198 s, 1 218 m, 1 242 w, 1 270 sh, 1 282 s, 1 305 m, 1 327 m, 1 344 m, 1 371 w, 1 466 m, 1 492 s, 1 533 m, 1 589 s, 1 667 s, 1 702 m, 1 785 s, 2 200 m, 2 853 w, 2 930 w, 2 988 m, 3 098 w, 3 421 m.

Arylhydrazonocyanacetamides *Ila–Ild*

a) By coupling (method A): The solution of diazonium salt prepared from the respective aromatic amine (as in preparation of hydrazone *J*) was added portionwise with stirring and cooling to a mixture prepared by dissolving 3.20 g (38.1 mmol) cyanacetamide in 400 ml water, subsequent dissolving 70 g sodium acetate, cooling to 0–3°C, and adding crushed ice. In the case of *Ilc* a solution of 600 mg (7.07 mmol) cyanacetamide and 10.5 g sodium acetate in 30 ml water was used. The mixture was left to stand at 0–3°C 100 h. The precipitated hydrazone was then collected by suction, thoroughly washed with water, and dried at 120°C. Recrystallization from ethanol or aqueous ethanol; for further data see Table I.

TABLE III
Arylhydrazonocyanacetamides *Ila–Ild*

Compound	Formula (mol.mass)	Calculated/Found			Yield, %		M.p., °C
		% C	% H	% N	<i>A</i>	<i>B</i>	
<i>Ila</i>	$C_{11}H_{10}N_4O_2$ (230.2)	57.38	4.38	24.34	73.8	66.0	223–225
		57.33	4.33	24.38			
<i>Ilb</i>	$C_{16}H_{12}N_4O_2$ (292.3)	65.75	4.14	19.17	75.2	73.5	256–258
		65.85	4.26	19.30			
<i>Ilc</i>	$C_{17}H_{12}N_4O_4$ (336.3)	60.17	3.60	16.66	75.1	65.4 ^a	280–282
		60.48	3.74	16.65			
<i>Ild</i>	$C_{17}H_{10}N_4O_3$ (318.3)	64.14	3.17	17.60	89.3	64.5	323–325
		64.01	3.20	17.40			

^a Pyridinium salt.

b) *By splitting of triazines III (method B)*: Mixture of 0.5 mmol triazine *III*, 25–75 ml water, and 2–3 ml pyridine was refluxed 50–80 h and cooled. After 24 h the precipitated hydrazone was collected by suction, washed with water, and dried at 120°C. After recrystallization from ethanol or aqueous ethanol the products were identical with the hydrazones *II* prepared by method *A*. The triazine *IIIc* gave in the mentioned way the pyridinium salt *IIC*. $C_{22}H_{17}N_5O_4$, yield 71%, m.p. 280–282°C (strong decomposition). For $C_{22}H_{17}N_5O_4$ (415.4) calculated: 63.61% C, 4.13% H, 16.86% N; found: 63.50% C, 4.06% H, 16.66% N. This pyridinium salt was treated with diluted hydrochloric acid and gave free hydrazone *IIC* identical with that obtained by method *A*. For further data see Table I.

2-(2-Acetylphenyl)-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitrile (*IIIa*)

Mixture of 305 mg (1.01 mmol) hydrazone *Ia*, 120 mg Na_2CO_3 , and 20 ml water was heated on boiling water bath 20 min, cooled, and acidified to pH 1. The precipitated solid was left to stand several hours at 10°C, collected by suction, washed with little water, and dried. Yield 198 mg (76.5%). After recrystallization from water m.p. 221–223°C. For $C_{12}H_8N_4O_3$ (256.2) calculated: 56.25% C, 3.15% H, 21.87% N; found: 56.32% C, 3.22% H, 21.81% N. IR spectrum (KBr, cm^{-1}): 454 w, 476 w, 518 w, 588 m, 615 m, 665 m, 684 w, 722 w, 753 w, 761 m, 779 w, 791 w, 834 w, 882 w, 964 m, 1 023 m, 1 047 w, 1 083 w, 1 150 w, 1 108 s, 1 254 s, 1 265 sh, 1 302 m, 1 335 s, 1 365 m, 1 415 m, 1 421 m, 1 440 m, 1 452 w, 1 490 m, 1 553 m, 1 570 sh, 1 577 m, 1 600 m, 1 677 sh, 1 687 s, 1 702 s, 1 723 sh, 1 738 s, 2 245 w, 2 833 w, 2 930 w, 3 079 m, 3 198 m.

2-(2-Benzoylphenyl)-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitrile (*IIIb*)

a) *By alkaline cyclization*: Mixture of 730 mg (2.0 mmol) hydrazone *Ib*, 350 mg Na_2CO_3 , and 30 ml water was heated on boiling water bath until dissolution and then for more 20 min. The solution was cooled and acidified to pH 1. After several hours the separated solid was collected by suction, washed with water, and dried. Yield 603 mg (94.6%). After recrystallization from aqueous ethanol m.p. 204–206°C.

b) *By thermal cyclization*: Mixture of 370 mg (1.02 mmol) hydrazone *Ib* and 15 ml decaline was refluxed 3 h and cooled. The other day the crystalline solid was collected by suction, washed with light petroleum, and dried. Yield 290 mg (89.7%). Several hours stirring of this product with solution of 200 mg $NaHCO_3$ in 70 ml water, filtration, and acidification of the filtrate to pH 1 gave 275 mg crystalline product, m.p. 204–206°C. For $C_{17}H_{10}N_4O_3$ (318.3) calculated: 64.14% C, 3.17% H, 17.60% N; found: 64.11% C, 3.06% H, 17.59% N. IR spectrum (KBr, cm^{-1}): 461 w, 490 w, 508 w, 563 m, 576 m, 619 m, 650 m, 664 w, 693 s, 715 w, 733 m, 741 m, 745 m, 786 m, 937 m, 942 m, 1 000 m, 1 040 w, 1 056 m, 1 084 m, 1 140 w, 1 172 s, 1 222 m, 1 247 s, 1 277 m, 1 286 w, 1 300 s, 1 387 m, 1 417 m, 1 463 s, 1 465 m, 1 558 m, 1 585 m, 1 647 s, 1 682 sh, 1 690 sh, 1 700 s, 1 725 s, 2 245 m, 3 093 m, 3 130 m, 3 200 m.

From the hydrazone *Ib* $1-^{15}N$ the alkaline cyclization gave the triazine *IIIb* $1-^{15}N$, too.

2-[2-(*o*-Carboxybenzoyl)phenyl]-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitrile (*IIIc*)

Mixture of 445 mg (1.00 mmol) hydrazone *Ic* dihydrate, 220 mg Na_2CO_3 , and 20 ml water was stirred until dissolution; the solution was left to stand at room temperature 21 days and then acidified to pH 1. After several hours the precipitated solid was collected by suction, washed with water, and dried in air. Yield 338 mg (93.3%). After recrystallization from water m.p. 257 to

259°C. For $C_{18}H_{10}N_4O_5$ (362.3) calculated: 59.67% C, 2.78% H, 15.47% N; found: 59.40% C, 2.55% H, 15.38% N. IR spectrum (KBr, cm^{-1}): 460 m, 488 w, 512 w, 530 w, 545 w, 580 s, 629 m, 648 m, 666 m, 670 w, 697 w, 714 s, 731 m, 766 sh, 770 s, 788 m, 801 w, 873 m, 932 s, 970 w, 1 011 m, 1 048 w, 1 078 m, 1 097 w, 1 155 sh, 1 160 m, 1 186 s, 1 258 m, 1 268 s, 1 291 s, 1 317 w, 1 412 s, 1 448 m, 1 482 m, 1 548 m, 1 578 m, 1 592 m, 1 660 s, 1 708 s, 1 750 s, 2 240 w, 2 806 w, 2 922 w, 3 020 m.

2-(9,10-Anthraquinon-1-yl)-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carbonitrile (*IIId*)

Mixture of 1.56 g (4.00 mmol) hydrazone *Id* and 15 ml nitrobenzene was refluxed 9 h and cooled. After several hours the separated solid was collected by suction, washed with little benzene, and dried. Yield 1.04 g (75.6%). Concentration of the mother liquor gave further 90 mg less pure fraction. After recrystallization from acetic acid m.p. 327–329°C. For analysis dried at 200°C. For $C_{18}H_8N_4O_4$ (344.3) calculated: 62.79% C, 2.34% H, 16.27% N; found: 62.78% C, 2.10% H, 16.29% N. IR spectrum (KBr, cm^{-1}): 430 w, 470 w, 521 w, 540 m, 582 s, 619 w, 648 m, 708 s, 738 m, 756 w, 773 m, 792 w, 809 m, 834 m, 852 w, 920 m, 968 m, 999 w, 1 041 w, 1 076 m, 1 171 m, 1 210 s, 1 243 w, 1 286 s, 1 318 s, 1 338 s, 1 417 m, 1 447 w, 1 468 m, 1 549 m, 1 588 s, 1 679 s, 1 706 s, 1 729 s, 1 756 s, 2 232 w, 2 913 w, 3 046 sh, 3 075 m.

2-Aryl-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carboxylic Acids *IVa–IVd*

Mixture of 0.5 mmol nitrile *IIIa–IIIc* and 30 ml 20% HCl was refluxed 3 h. For the same amount of nitrile *IIId* 35 ml acetic acid and 25 ml 37% HCl were used and the time increased to 6 h. Then the mixture was evaporated in vacuum, the residue was mixed with little water, and the crystalline solid was collected by suction after several hours, washed with little water, and dried in air. The acid *IVa* was obtained as the monohydrate, the other *IV* were anhydrous. For ana-

TABLE IV

2-Aryl-3,5-dioxo-2,3,4,5-tetrahydro-1,2,4-triazine-6-carboxylic acids (*IVa–IVd*)

Compound	Formula (mol.mass)	Calculated/Found			Yield %	M.p., °C
		% C	% H	% N		
<i>IVa</i>	$C_{12}H_{11}N_3O_6$ (293.2)	49.15	3.78	14.33	67.5 ^a	196–198
		49.44	3.58	14.60		
<i>IVb</i>	$C_{17}H_{11}N_3O_5$ (337.3)	60.53	3.29	12.46	87.0	117–119
		60.47	3.46	12.32		
<i>IVc</i>	$C_{18}H_{11}N_3O_7$ (381.3)	56.70	2.91	11.02	87.5	265–267
		56.95	2.66	11.16		
<i>IVd</i>	$C_{18}H_9N_3O_6$ (363.3)	59.51	2.50	11.57	89.4	276–278
		59.57	2.64	11.38		

^a Monohydrate.

lyses the acids *IVa*–*IVc* were recrystallized from water or aqueous ethanol, *IVd* from acetic acid. Increased hydrolysis time of nitriles *IIIb* and *IIIc* resulted in obtaining small amounts of the derivatives *Vb* and *Vd* on extraction of the evaporation residues with dilute Na_2CO_3 solution. For further data see Table II.

3-Methylindazole (*Va*)

Mixture of 305 mg (1.01 mmol) hydrazone *Ia* and 30 ml 20% HCl was refluxed 10 h and evaporated in vacuum. The residue was mixed with 2 ml 2% aqueous ammonia, the crystalline solid formed was collected by suction after several hours, washed with little water, and dried. Yield 95 mg (71.2%). After recrystallization from hexane m.p. 112–113°C in accordance with ref.¹⁸. The derivative *Va* was obtained from hydrazone *IIa* in the same way and yield.

3-Phenylindazole (*Vb*)

Mixture of 365 mg (1.00 mmol) hydrazone *Ib* and 60 ml 20% HCl was refluxed 24 h, cooled, and treated with 25% NH_3 to pH 8. After several hours the crystalline solid was collected by suction, washed with water, and dried. Yield 190 mg (97.6%). After recrystallization from cyclohexane m.p. 115–116°C which agrees with the melting point¹² of the higher-melting modification. IR spectrum (KBr, cm^{-1}): 428 m, 475 m, 518 m, 562 w, 582 m, 617 m, 665 w, 701 s, 743 s, 750 s, 777 sh, 781 s, 847 w, 906 s, 918 m, 942 w, 988 m, 1 010 s, 1 032 m, 1 074 m, 1 108 s, 1 135 m, 1 221 w, 1 258 s, 1 309 m, 1 346 s, 1 364 m, 1 418 m, 1 444 m, 1 455 w, 1 479 s, 1 503 s, 1 512 w, 1 582 w, 1 605 m, 1 622 s, 2 880 m, 2 934 m, 3 120 m, 3 173 s, broad. IR spectrum (CS_2 , cm^{-1}): 478 w, 516 m, 577 m, 616 m, 670 sh, 678 s, 696 s, 705 sh, 743 s, 750 m, 778 s, 907 m, 916 m, 987 m, 1 009 m, 1 032 m, 1 105 m, 1 133 m, 1 152 m, 1 249 m, 1 257 m, 1 307 w, 1 341 sh, 1 344 s, 1 359 w, 1 618 m, 2 850 w, 2 875 w, 2 892 w, 2 914 m, 2 964 w, 2 974 w, 3 071 m, 3 119 m, 3 213 w, 3 461 m.

The lower-melting modification (m.p. 107–108°C) was obtained by dissolving the higher-melting one in warm 15% HCl and precipitating with 25% NH_3 . IR spectrum (KBr, cm^{-1}): 429 m, 478 w, 518 m, 522 m, 561 w, 681 m, 618 m, 665 w, 699 s, 767 s, 777 s, 782 s, 843 w, 858 m, 907 s, 918 m, 942 w, 973 w, 983 m, 1 008 s, 1 032 m, 1 076 m, 1 105 s, 1 134 m, 1 154 m, 61 w, 1 257 s, 1 308 m, 1 346 s, 1 362 m, 1 419 w, 1 443 m, 1 458 w, 1 479 s, 1 502 m, 1 570 w, 1 603 m, 1 622 s, 2 870 w, 2 917 m, 2 935 m, 3 122 m, 3 170 s. IR spectrum in CS_2 solution is identical with that of the higher-melting modification in the same solvent.

The mentioned procedure was also used for preparation of 3-phenylindazole *Vb* 2-¹⁵N from hydrazone *Ib* 1-¹⁵N. IR spectrum (CS_2 , cm^{-1}): 477 m, 515 m, 576 m, 616 m, 674 m, 697 s, 705 sh, 743 s, 750 m, 770 s, 778 s, 843 w, 905 m, 916 m, 984 m, 990 sh, 1 008 m, 1 032 m, 1 072 m, 1 097 m, 1 130 m, 1 150 m, 1 253 s, 1 306 m, 1 341 sh, 1 344 s, 1 359 m, 1 620 m, 2 974 w, 3 071 m, 3 119 m, 3 162 m, 3 213 w, 3 461 m. The derivative *Vb* was obtained from hydrazone *IIb* in the same way and similar yield, too.

2-(3-Indazolyl)benzoic Acid (*Vc*)

Mixture of 445 mg (1.00 mmol) hydrazone *Ic* dihydrate and 50 ml 20% HCl was refluxed 30 h and evaporated in vacuum. The residue was mixed with 5 ml water, after several hours the crystalline solid was collected by suction, washed with water, and dried in air. Yield 245 mg monohydrate (95.5%), m.p. 132–134°C. For $\text{C}_{14}\text{H}_{12}\text{N}_2\text{O}_3$ (256.2) calculated: 65.62% C, 4.72% H, 10.93% N; found: 65.47% C, 3.85% H, 10.64% N. Recrystallization from acetic acid and drying at 120°C gave the anhydrous product, m.p. 185–187°C in accordance with ref.¹⁹.

2,6-Dihydronaphtho[1,2,3-*c,d*]indazol-6-one (*Vd*)

Mixture of 390 mg (1.00 mmol) hydrazone *Id*, 60 ml acetic acid, and 60 ml 37% HCl was refluxed 60 h and evaporated in vacuum. The evaporation residue was mixed with 10 ml 2% NH₃, the crystalline precipitate was collected by suction after several hours, washed with water, and dried at 150°C. Yield 187 mg (85.0%). After recrystallization from nitrobenzene m.p. 278–280°C in accordance with ref.²⁰.

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