Synthesis of 4-arylcarbamoyl-5-(2-hydroxynaphthylazo)imidazoles and 1-substituted naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines

E. V. Sadchikova and V. S. Mokrushin*

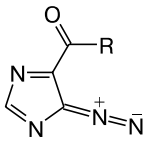
Ural State Technical University — UPI,
19 ul. Mira, 620002 Ekaterinburg, Russian Federation.
Tel: +7 (343) 375 9789. E-mail: selena@htf.ustu.ru

The reactions of β-naphthol with 5-diazoimidazoles and imidazolyl-5-diazonium salts containing chemically different carboxamide groups in position 4 were studied. Heterocyclization of 4-arylcarbamoyl-5-(2-hydroxynaphthylazo)imidazoles formed in these reactions was investigated. The presence of the NH fragment in the amide group prevents this process, the reaction giving instead 3-substituted 3,7-dihydroimidazo[4,5-*d*][1,2,3]triazin-4-ones, which is due to reversibility of *C*-azo coupling. Methods for modification of 1-ethoxycarbonyl group in the naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine system were developed and used to prepare substituted carboxamides inaccessible by other routes.

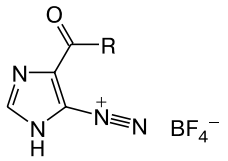
Key words: 5-diazoimidazoles, 5-imidazolyldiazonium salts, *C*-azo coupling, reactivity, azo compounds, naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines.

It is known[1,2] that azo compounds based on diazonium derivatives of pyrazole, triazole, tetrazole, and phenols or naphthols undergo intramolecular cyclization upon refluxing in methanol, glacial acetic acid, or 2 *M* sulfuric acid to give azolotriazines, whereas in the reaction of 2-diazoimidazole with β-naphthols, the cyclization product is formed already under azo coupling conditions.

The purpose of this work is to study the reactivity of 5-diazoimidazole-4-carboxamides **1a—h** and imidazolyl-5-diazonium salts **2a—d** containing chemically different substituents in the carboxamide fragment toward β-naphthol and to synthesize new naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines based on the *C*-azo coupling products obtained.



1a—h



2a—d

1a—h, 2a—d: R = NHC_6H_4Z, Z = *p*-Me (**a**), *p*-Cl (**b**), *p*-OMe (**c**), *p*-COOEt (**d**); R = NHC_6H_{11} (**e**), NHMe (**f**), —N O (**g**), —N (**h**)

It should be emphasized that, when performing azo coupling with 5-diazoimidazoles **1a—f** having an NH fragment in the amide function, one should be aware of the possible formation of intramolecular cyclization products, namely, imidazo[4,5-*d*][1,2,3]triazin-4-ones. This type of cyclization is known[3] to take place almost instantaneously in highly acidic or alkaline media (pH <1, pH >7) or on heating and to be retarded at pH values from 1 to 6 and temperatures not exceeding room temperature.

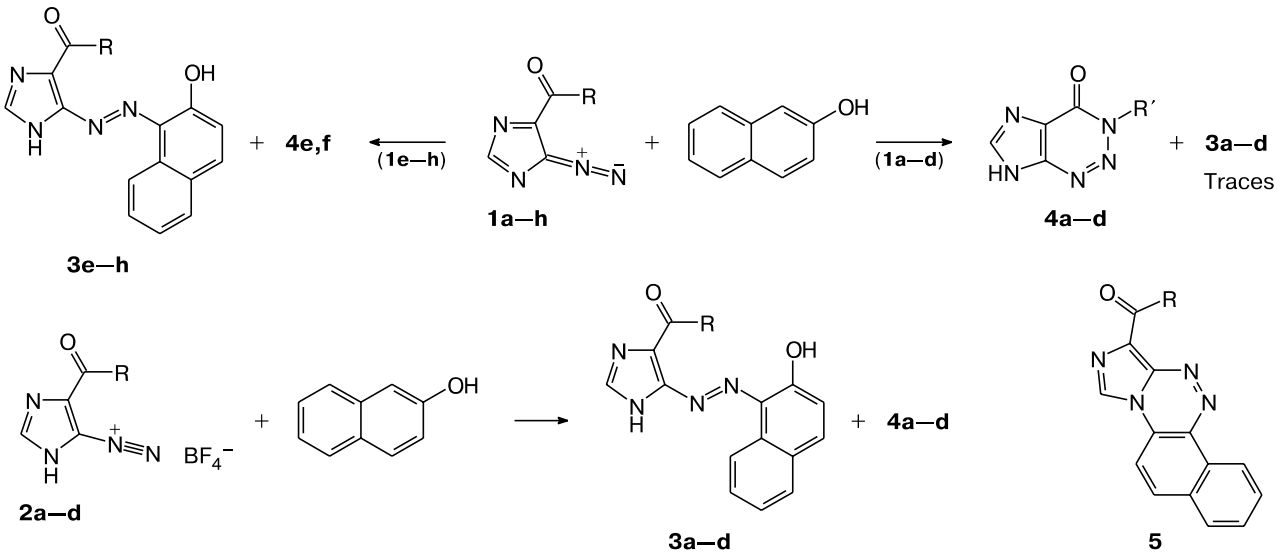
Our study of the reactions of 5-diazoimidazole-4-(*N*-substituted)carboxamides **1a—h** with β-naphthol has shown that the formation rate and the yields of products are markedly affected by the structure of the carboxamide substituent. By long-term keeping of the reaction mixture at room temperature in dry acetonitrile, we were able to couple β-naphthol only with diazoimidazoles **1e—h** containing aliphatic substituents in the amide part of the molecule (Scheme 1). This gave 5-(2-hydroxynaphthylazo)-4-morpholinocarbonylimidazole (**3g**) and 5-(2-hydroxynaphthylazo)-4-piperidinocarbonylimidazole (**3h**) in 54 and 48% yields, respectively (Table 1). Azo compounds **3e,f** were formed together with imidazo[4,5-*d*][1,2,3]triazin-4-ones **4e,f** in 33 and 42% yields, respectively. However, upon the reaction of 5-diazoimidazole-4-(*N*-aryl)carboxamides **1a—d** with naphthol under similar conditions, only traces of azo compounds were detected by chromatography. Only 3-substituted 3,7-dihydroimidazo[4,5-*d*][1,2,3]triazin-4-ones **4a—d** were isolated from the reaction mixture in 80—85% yields. This prompts the conclusion that the rate of the competing intramolecular cyclization is much higher than the rate of azo coupling of the starting diazo compound **1a—d** with aromatic azo components.

Previously, we have shown[4] that azolyldiazonium salts are more reactive in *C*-azo coupling than diazoazoles. In

Published in Russian in *Izvestiya Akademii Nauk. Seriya Khimicheskaya,* No. 7, pp. 1208—1213, July, 2006.

1066-5285/06/5507-1255

Scheme 1



1a—f, 2a—d, 3a—f: R = NHR′

Compound	R′	Compound	R′	Compound	R′	Compound	R	Compound	R
1a—5a	C_6H_4Me-*p*	**1c—4c**	C_6H_4OMe-*p*	**1e—5e**	C_6H_{11}	**1g**, **3g**, **5g**	—N O	**5c**	Ph
1b—5b	C_6H_4Cl-*p*	**1d—4d**	C_6H_4COOEt-*p*	**1f—5f**	Me	**1h**, **3h**, **5h**	—N	**5d**	H

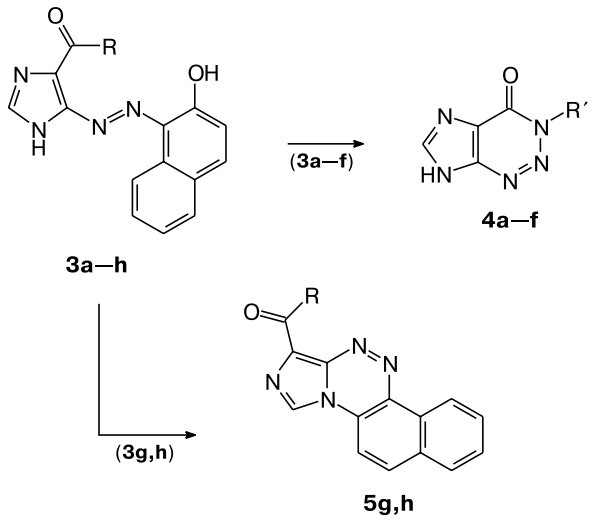
view of this fact, we studied the reaction of diazonium fluoroborates **2a—d** with β-naphthol (see Scheme 1) and demonstrated that the reaction carried out in anhydrous acetonitrile proceeds to completion over 3—5 h to afford 4-arylcarbamoyl-5-(2-hydroxynaphthylazo)imidazoles **3a—d** in 50—60% yields. As by-products, the reaction gives 3-phenylaza-6-hydroxypurine derivatives **4a—d** (20—33%), which are difficult to remove from the target azo compounds. By conducting the reaction in glacial acetic acid, the yield of compounds **3a—d** was increased to 82—90% and the problems related to product separation were eliminated.

It should be emphasized that unlike 2-diazoimidazoles,[1] coupling of 5-diazoimidazoles **1a—h** and imidazolyl-5-diazonium salts **2a—d** in glacial acetic acid at room temperature gave azo compounds **3a—d** rather than naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines **5**.

In order to obtain new analogs of this heterocyclic system, we investigated the behavior of azo compounds **3a—h** in boiling acetic acid. Only derivatives **3g,h** did give 1-morpholinocarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5g**) and 1-piperidinocarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*]-[1,2,4]triazine (**5h**) in 80 and 75% yields, respectively (Scheme 2).

When azo compounds **3a—e** were involved in this reaction, as in the case of compound **3f** described previously,[5] imidazo[4,5-*d*][1,2,3]triazin-4-ones **4a—e** were

Scheme 2



isolated from the reaction mixture in almost quantitative yield, which is attributable to reversibility of *C*-azo coupling.[5]

Since derivatives **5a—f** cannot be prepared by direct cyclization of the corresponding 4-substituted 5-(2-hydroxynaphthylazo)imidazoles **3a—f**, we attempted to modify the ester group in 1-ethoxycarbonyl-

Table 1. Yields, melting points, and elemental analysis data

Compound	Yield (%)	M.p. /°C	τ*/h (Method)	Found / Calculated (%)**			Molecular formula
				C	H	N	
3a	58	> 300	3 (*A*)	68.15	4.48	18.51	$C_{21}H_{17}N_5O_2$
	90		1 (*B*)	67.91	4.61	18.86	
3b	56	>300	3.5 (*A*)	61.32	3.46	17.59	$C_{20}H_{14}ClN_5O_2$
	80		2 (*B*)	61.31	3.60	17.87	
3c	65	216—217	3 (*A*)	67.07	4.15	20.03	$C_{20}H_{15}N_5O_2$
	84		2 (*B*)	67.22	4.23	19.60	
3d	51	185—187	4.5 (*A*)	64.51	4.34	16.54	$C_{23}H_{19}N_5O_4$
	82		2 (*B*)	64.33	4.46	16.31	
3e	33	245—248	360 (*A*)	66.21	6.02	18.94	$C_{20}H_{21}N_5O_2$
				66.10	5.82	19.27	
3f	42	276—278	480 (*A*)	61.34	4.21	23.92	$C_{15}H_{13}N_5O_2$
				61.01	4.44	23.72	
3g	54	224—226	432 (*A*)	61.40	4.79	20.19	$C_{18}H_{17}N_5O_3$
				61.53	4.88	19.93	
3h	48	200—202	768 (*A*)	65.39	5.52	20.15	$C_{19}H_{19}N_5O_2$
				65.32	5.48	20.04	
5a	50	>300	8	71.52	4.19	20.03	$C_{21}H_{15}N_5O$
				71.38	4.28	19.82	
5b	54	>300	8	64.18	3.23	18.71	$C_{20}H_{12}ClN_5O$
				64.26	3.24	18.74	
5c	47	277—279	8	80.05	3.81	20.60	$C_{20}H_{13}N_5O$
				70.79	3.86	20.64	
5d	77	295—297	6	63.90	3.47	26.31	$C_{14}H_9N_5O$
				63.87	3.45	26.60	
5e	63	299—300	0.5	69.60	5.45	19.94	$C_{20}H_{19}N_5O$
				69.55	5.54	20.28	
5f	90	286—289	5 (*A*)	65.10	4.03	25.34	$C_{15}H_{11}N_5O$
	93		1 (*B*)	64.97	4.00	25.26	
5g	80	>300	2	64.80	4.59	21.15	$C_{18}H_{15}N_5O_2$
				64.86	4.54	21.01	
5h	75	>300	2	68.73	5.15	20.93	$C_{19}H_{17}N_5O$
				68.87	5.17	21.13	
5i	85	289—291	0.5	65.88	4.12	19.25	$C_{16}H_{12}N_4O_2$
				65.75	4.14	19.17	
5j	83	>300	7	60.27	3.54	30.55	$C_{14}H_{10}N_6O$
				60.43	3.62	30.20	
5k	95	310—312	0.25	64.07	4.46	26.32	$C_{17}H_{14}N_6O$
				64.14	4.43	26.40	
5l	94	196—199	2.5	57.79	2.53	34.15	$C_{14}H_7N_7O$
				58.13	2.44	33.90	
5n	82	274—276	2	62.64	4.30	22.74	$C_{16}H_{13}N_5O_2$
				62.53	4.26	22.79	

* Reaction time.

** Found/calculated (%), Cl: 9.16/9.05 (**3b**), 9.52/9.48 (**5b**).

naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine[6] (**5i**). Heating of compound **5i** in an ethanol solution of methylamine or hydrazine hydrate for 6—8 h gave cyclic products **5f** (R = NHMe) and **5j** (R = $NHNH_2$), respectively, in high yields, whereas aromatic amines did not react. The structure of the synthesized carbohydrazide **5j** was confirmed by elemental analysis, ^{1}H NMR, and IR spectroscopy (see Tables 1 and 2) and by the reaction with a carbonyl compound, which afforded 1-isopropylidenecarbohydrazidonaphtho[2,1-*e*]azolo[5,1-*c*][1,2,4]triazine (**5k**).

We developed a synthetic route to naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines **5a—f**, which cannot be obtained by direct cyclization of azo compounds **3a—f**, on the basis

Table 2. Spectral characteristics of 4-*R*-5-(2′-hydroxynaphthyl)azoimidazoles (**3a—h**) and naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines (**5a—n**)

Compound	IR,* ν/cm^{-1}			^{1}H NMR, δ (*J*/Hz)
	C=O	N=N, C=N	NH	
3a	1645	1600, 1585	3435, 3360	2.33 (s, 3 H, Me); 7.04 (d, 1 H, H(3″), *J* = 9.2); 7.12 (d, 2 H, H(3′), H(5′), *J* = 7.9); 7.43 (dd, 1 H, H(7″), J_1 = 7.4, J_2 = 8.3); 7.59 (dd, 1 H, H(6″), J_1 = 7.4, J_2 = 7.7); 7.75 (s, 1 H, H(2)); 7.77 (d, 2 H, H(2′), H(6′), *J* = 7.9); 7.90 (m, 2 H, H(4″), H(5″)); 8.88 (d, 1 H, H(8″), *J* = 8.3); 9.68 (s, 1 H, NH); 13.48 (br.s, 1 H, OH); 14.93 (br.s, 1 H, NH)
3b	1660	1620, 1600	3450, 3380	7.05 (d, 1 H, H(3″), *J* = 9.0); 7.42 (d, 2 H, H(3′), H(5′), *J* = 8.6); 7.48—7.84 (m, 3 H, H(5″), H(6″), H(7″)); 7.92 (d, 2 H, H(2′), H(6′), *J* = 8.6); 7.98 (d, 1 H, H(4″), *J* = 9.0); 8.32 (s, 1 H, H(2)); 8.87 (d, 1 H, H(8″), *J* = 8.0); 10.28 (s, 1 H, NH); 11.48 (br.s, 1 H, OH); 14.84 (br.s, 1 H, NH)
3c	1660	1630, 1605	3350, 3380	7.07 (d, 1 H, H(3″), *J* = 9.2); 7.25—7.67 (m, 7 H, H(2′), H(3′), H(4′), H(5′), H(6′), H(6″), H(7″)); 7.85 (s, 1 H, H(2)); 8.05 (m, 2 H, H(4″), H(5″)); 8.97 (d, 1 H, H(8″), *J* = 7.7); 9.52 (s, 1 H, NH); 11.91 (br.s, 1 H, OH); 13.50 (br.s, 1 H, NH)
3d	1680, 1650	1610, 1590	3450	1.37 (t, 3 H, OCH$_2$<u>Me</u>, *J* = 7.0); 4.31 (q, 2 H, OC<u>H</u>$_2$Me, *J* = 7.0); 6.98 (d, 1 H, H(3″), *J* = 9.5); 7.42 (dd, 1 H, H(7″), J_1 = 7.0, J_2 = 8.2); 7.56 (dd, 1 H, H(6″), J_1 = 7.0, J_2 = 7.6); 7.73 (d, 1 H, H(5″), *J* = 7.6); 7.89 (d, 1 H, H(4″), *J* = 9.5); 7.95 (s, 4 H, H(2′), H(3′), H(5′), H(6′)); 8.28 (s, 1 H, H(2)); 8.83 (d, 1 H, H(8″), *J* = 8.2); 10.17 (s, 1 H, NH); 13.28 (br.s, 1 H, OH); 14.74 (br.s, 1 H, NH)
3e	1650	1610, 1580	3420, 3360	1.11—1.84 (m, 10 H, 5 CH$_2$); 3.69 (m, 1 H, CH); 6.92 (d, 1 H, H(3′), *J* = 9.2); 7.37 (dd, 1 H, H(7′), J_1 = 7.3, J_2 = 7.1); 7.62 (dd, 1 H, H(6′), J_1 = 7.3, J_2 =7.3); 7.75 (d, 1 H, H(5′), *J* = 7.3); 7.89 (d, 1 H, H(4′), *J* = 9.2); 8.04 (s, 1 H, H(2)); 8.86 (dd, 1 H, H(8′), *J* = 7.1); 9.16 (m, 1 H, N<u>H</u>C$_6$H$_{11}$); 11.54 (br.s, 1 H, OH); 13.87 (br.s, 1 H, NH)
3f	1660	1620, 1590	3370, 3350	3.93 (d, 3 H, NH<u>Me</u>, *J* = 4.9); 6.95 (d, 1 H, H(3′), *J* = 9.0); 7.16—7.70 (m, 3 H, H(5′), H(6′), H(7′)); 7.90 (d, 1 H, H(4′), *J* = 9.0); 8.13 (s, 1 H, H(2)); 8.85 (dd, 1 H, H(8′), *J* = 7.4); 9.52 (q, 1 H, N<u>H</u>Me, *J* = 4.9); 9.82 (s, 1 H, OH); 12.42 (br.s, 1 H, NH); 13.90 (br.s, 1 H, NH)
3g	1630	1600	3450	3.69 (m, 6 H, 3 CH$_2$); 3.91 (m, 2 H, CH$_2$); 6.94 (d, 1 H, H(3′), *J* = 9.2); 7.41 (dd, 1 H, H(6′), J_1 = 8.8, J_2 = 7.7); 7.56 (dd, 1 H, H(7′), J_1 = 7.4, J_2 =7.7); 7.72 (d, 1 H, H(4′), *J* = 9.2); 7.77 (s, 1 H, H(2)); 7.85 (d, 1 H, H(5′), *J* = 8.8); 8.81 (d, 1 H, H(8′), *J* = 7.4); 13.31 (s, 1 H, OH); 14.85 (br.s, 1 H, NH)
3h	1630	1600	3450	1.62 (m, 6 H, 3 CH$_2$); 3.79 (m, 4 H, 2 CH$_2$); 6.99 (d, 1 H, H(3′), *J* = 9.2); 7.39 (dd, 1 H, H(7′), J_1 = 7.3, J_2 = 7.1); 7.55 (dd, 1 H, H(6′), J_1 =7.3, J_2 =8.2); 7.73 (d, 1 H, H(5′), *J* = 8.2); 7.76 (s, 1 H, H(2)); 7.84 (d, 1 H, H(4′), *J* = 9.2); 8.77 (d, 1 H, H(8′), *J* =7.1); 13.23 (s, 1 H, OH); 14.60 (br.s, 1 H, NH)
5a	1635	1605, 1580	3260	2.27 (s, 3 H, Me); 7.12 (d, 2 H, H(3′), H(5′), *J* = 8.4); 7.45 (d, 2 H, H(2′), H(6′), *J* = 8.4); 7.80 (dd, 1 H, H(8), J_1 = 8.0, J_2 = 6.8); 7.92 (dd, 1 H, H(9), J_1 = 8.4, J_2 = 6.8); 8.19 (d, 1 H, H(7), *J* = 8.0); 8.48 (s, 2 H, H(5), H(6)); 9.26 (s, 1 H, H(3)); 9.31 (d, 1 H, H(10), *J* = 8.4); 9.83 (br.s, 1 H, NH)
5b	1640	1615, 1585	3275	7.34 (d, 2 H, H(3′), H(5′), *J* = 8.8); 7.58 (d, 2 H, H(2′), H(6′), *J* = 8.8); 7.77 (dd, 1 H, H(8), J_1 = 8.0, J_2 = 7.3); 7.90 (dd, 1 H, 9(H), J_1 = 7.8, J_2 = 7.3); 8.16 (d, 1 H, H(7), *J* = 8.0); 8.39 (d, 1 H, H(6), *J* = 9.0); 8.44 (d, 1 H, H(5), *J* = 9.0); 9.16 (s, 1 H, H(3)); 9.31 (d, 1 H, H(10), *J* = 7.8); 9.71 (br.s, 1 H, NH)
5c	1640	1610, 1580	3275	7.02—7.54 (m, 5 H, m, H(2′), H(3′), H(4′), H(5′), H(6′)); 7.65 (dd, 1 H, H(8), J_1 = 6.5, J_2 = 6.8); 7.88 (dd, 1 H, H(9), J_1 = 6.8, J_2 = 8.2); 8.14 (d, 1 H, H(7), *J* = 6.5); 8.37 (d, 1 H, H(6), *J* = 9.0); 8.42 (d, 1 H, H(5), *J* = 9.0); 9.14 (d, 1 H, H(10), *J* = 8.2); 9.15 (s, 1 H, H(3))
5d	1680	1630, 1595	3360, 3310, 3200	7.55 (br.s, 2 H, NH$_2$); 7,83 (dd, 1 H, 9(H), J_1 = 8.3, J_2 = 7.8); 7.94 (dd, 1 H, H(8), J_1 = 8.0, J_2 = 7.8); 8.21 (d, 1 H, H(7), *J* = 8.0); 8.52 (d, 1 H, H(6), *J* = 9.0); 8.58 (d, 1 H, H(5), *J* = 9.0); 9.35 (s, 1 H, H(3)); 9.41 (d, 1 H, H(10), *J* = 8.3)
5e	1650	1615, 1580	3410	1.29—1.99 (m, 10 H, 5CH$_2$); 3.98 (m, 1 H, CH); 7.82 (dd, 1 H, H(8), J_1 = 8.0, J_2 = 6.8); 7.96 (dd, 1 H, H(9), J_1 = 9.3, J_2 = 6.8); 8.10 (d, 1 H, NH, *J* = 8.0); 8.20 (d, 1 H, H(7), *J* = 8.0); 8.52 (d, 1 H, H(6), *J* = 9.0); 8.57 (d, 1 H, H(5), *J* = 9.0); 9.35 (s, 1 H, H(3)); 9.38 (d, 1 H, H(10), *J* = 9.3)

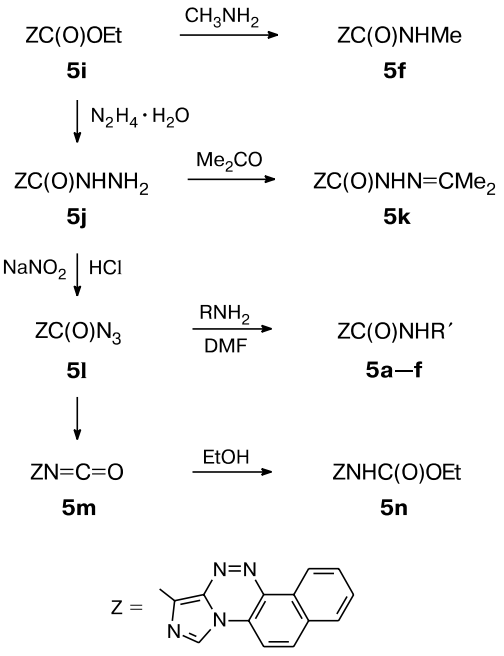
(*to be continued*)

Table 2 (*continued*)

Compound	IR,* ν/cm^{-1}			^{1}H NMR, δ (*J*/Hz)
	C=O	N=N, C=N	NH	
5f	1660	1620, 1590	3350	3.87 (d, 3 H, NHMe, *J* = 4.9,); 7.78—7.97 (m, 3 H, H(7), H(8), H(9)); 8.31 (d, 1 H, H(6), *J* = 9.0); 8.40 (d, 1 H, H(5), *J* = 9.0); 9.24 (q, 1 H, NHMe, *J* = 4.9); 9.38 (d, 1 H, H(10), *J* = 8.3); 9.43 (s, 1 H, H(3))
5g	1610	1590	—	3.42 (m, 8 H, 4 CH_2); 7.82 (dd, 1 H, H(8), J_1 = 7.0, J_2 = 7.9); 7.96 (dd, 1 H, H(9), J_1 = 8.2, J_2 = 7.0); 8.21 (d, 1 H, H(7), *J* = 7.9); 8.51 (d, 1 H, H(6), *J* = 9.3); 8.57 (d, 1 H, H(5), *J* = 9.3); 9.37 (s, 1 H, H(3)); 9.40 (d, 1 H, H(10), *J* = 8.2)
5h	1610	1590	—	1.66 (m, 6 H, 3 CH_2); 3.07 (m, 4 H, 2 CH_2); 7.83 (dd, 1 H, H(9), J_1 = 8.1, J_2 = 7.0); 7.96 (dd, 1 H, H(8), J_1 = 7.0, J_2 = 7.9); 8.22 (d, 1 H, H(7), *J* = 7.9); 8.51 (d, 1 H, H(6), *J* = 9.0); 8.57 (d, 1 H, H(5), *J* = 9.0); 9.36 (s, 1 H, H(3)); 9.40 (d, 1 H, H(10), *J* = 8.1)
5i	1680	1620, 1580	—	1.43 (t, 3 H, OCH_2Me, *J* = 7.0); 4.48 (q, 2 H, OCH_2Me, *J* = 7.0); 7.85 (dd, 1 H, H(8), J_1 = 8.0, J_2 = 7.0); 7.99 (dd, 1 H, H(9), J_1 = 8.3, J_2 = 7.0); 8.23 (d, 1 H, H(7), *J* = 8.0); 8.57 (d, 1 H, H(6), *J* = 9.3); 8.63 (d, 1 H, H(5), *J* = 9.3); 9.40 (d, 1 H, H(10), *J* = 8.3); 9.47 (s, 1 H, H(3))
5j	1635	1610, 1580	3325, 3260	7.84 (dd, 1 H, H(8), J_1 = 8.3, J_2 = 7.8); 7.98 (dd, 1 H, H(9), J_1 = 8.5, J_2 = 7.8); 8.23 (d, 1 H, H(7), *J* = 8.3); 8.55 (d, 1 H, H(6), *J* = 9.0); 8.62 (d, 1 H, H(5), *J* = 9.0); 9.39 (d, 1 H, H(10), *J* = 8.5); 9.44 (s, 1 H, H(3)); 9.70 (br.s, 1 H, NH)
5k	1665	1630, 1610	3280	2.07 (s, 6 H, 2 Me); 7.80 (dd, 1 H, H(8), J_1 = 7.3, J_2 = 7.8); 7.93 (dd, 1 H, H(9), J_1 = 8.2, J_2 = 7.8); 8.18 (d, 1 H, H(7), *J* = 7.3); 8.56 (d, 2 H, H(5), H(6), *J* = 8.9); 9.31 (d, 1 H, H(10), *J* = 8.2); 9.45 (s, 1 H, H(3)); 10.80 (br.s, 1 H, NH)
5l	1660	1625, 1575	—	7.92 (dd, 1 H, H(9), J_1 = 9.2, J_2 = 6.8); 8.03 (dd, 1 H, H(8), J_1 = 8.4, J_2 = 6.8); 8.29 (d, 1 H, H(7), *J* = 8.4); 8.64 (d, 1 H, H(6), *J* = 8.8); 8.72 (d, 1 H, H(10), *J* = 9.2); 9.46 (d, 1 H, H(5), *J* = 8.8); 9.57 (s, 1 H, H(3))
5n	1685	1580	3230	1.29 (t, 3 H, OCH_2Me, *J* = 7.0); 4.20 (q, 2 H, OCH_2Me, *J* = 7.0); 7.76 (dd, 1 H, H(8), J_1 = 7.9, J_2 = 7.0); 7.89 (dd, 1 H, H(9), J_1 = 8.2, J_2 = 7.0); 8.14 (d, 1 H, H(7), *J* = 7.9); 8.44 (d, 1 H, H(6), *J* = 8.9); 8.46 (d, 1 H, H(5), *J* = 8.9); 9.20 (s, 1 H, H(3)); 9.27 (d, 1 H, H(10), *J* = 8.2); 10.11 (br.s, 1 H, NH)

* Other groups: **5k** — 3080 cm^{-1} (Me), **5l** — 2140 cm^{-1} (N_3).

Scheme 3



of compound **5i** (Scheme 3). This route includes two consecutive chemical reactions, namely, nitrosation of compound **5j** at the carbohydrazide group to give azide **5l** followed by nucleophilic displacement of the azide group upon the reaction with aromatic and aliphatic amines (see Scheme 3).

Compound **5l** enters into the Curtius reaction to give isocyanate **5m**, whose formation was proved by converting it into urethane **5n** by refluxing in ethanol. It is noteworthy that, unlike the acyl azide derivative of imidazotetrazine, for which a reactivity study did not give[7] any products, in this case we were able to prepare a broad range of new compounds by modification of substituents in the imidazole ring incorporated in a polycyclic condensed system.

Experimental

Spectroscopic studies were carried out using analytically and chromatographically pure samples. IR spectra of the synthesized compounds were recorded on a Specord IR-75 instrument (KBr pellets). ^{1}H NMR spectra were recorded on a Bruker WR-250 instrument (250 MHz) in a DMSO-d_6—CCl_4 (δ scale,

Me_4Si as the internal standard). The reactions were monitored and the purity of the compounds was checked by TLC on Silufol UV-254 and Sorbfil UV-254 plates (silica gel STKh-1A as the sorbent) in the following solvent systems: BuOH—AcOH—H_2O, 4 : 1 : 1 (I); $CHCl_3$—EtOH, 3 : 1 (II); $CHCl_3$—EtOH, 10 : 1 (III).

The results of elemental analysis of the obtained compounds (C, H, N) correspond to calculated values (see Table 1). The spectral characteristics of the synthesized compounds are presented in Table 2. The melting points were not corrected. The starting diazoazoles **1a—h** and diazonium salts **2a—d** were prepared from the corresponding heterocyclic amines.[8]

5-(2-Hydroxynaphthylazo)imidazole-4-(*N*-aryl)carboxamides (3a—d) (general procedure). ***A.*** β-Naphthol (0.52 g, 3.6 mmol) was added at room temperature to a stirred solution of diazonium salt **2a—d** (3 mmol) in anhydrous MeCN (5 mL). After 3—5 h, the solvent was evaporated *in vacuo*, the residue was washed with methyl *tert*-butyl ether (its evaporation gave 0.13—0.17 g of unreacted β-naphthol) and with hot ethanol (its evaporation gave 0.14—0.25 g (20—35%) of 3-aryl-3,7-dihydroimidazo[4,5-d][1,2,3]triazin-4-one **4a—d**). The precipitated 4-arylcarbamoyl-5-(2-hydroxynaphthylazo)imidazole **3a—d** was filtered off, crystallized from ethanol, and dried. Yield 50—60%.

B. β-Naphthol (0.52 g, 3.6 mmol) was added at room temperature to a stirred solution of diazonium salt **2a—d** (3 mmol) in glacial AcOH (5 mL). Within 1.5—2 h, a precipitate was formed, which was filtered off and washed with ether. Yield 82—90%.

Reactions of 5-diazoimidazole-4-(*N*-aryl)carboxamides 1a—d with β-naphthol (general procedure). β-Naphthol (0.076 g, 0.53 mmol) was added at room temperature to a stirred solution of diazo compound **1a—d** (0.44 mmol) in anhydrous MeCN (5 mL). The precipitate formed within 48 h was filtered off, crystallized from ethanol, and dried. The yields of 3-aryl-3,7-dihydroimidazo[4,5-d][1,2,3]triazin-4-ones **4a—d** were 80—86%. In the case of diazoimidazole **1b**, azo compound **3b** was isolated in 12.7% yield apart from imidazotriazinone **4b**.

4-*R*-5-(2-Hydroxynaphthylazo)imidazoles (3e—h) (general procedure). β-Naphthol (0.52 g (3.6 mmol) was added at room temperature to a stirred solution of diazo compound **1e—h** (3 mmol) in $CHCl_3$ or MeCN. The reaction mixture was kept until the starting diazoimidazole **1e—h** disappeared (see Table 1). The precipitate formed in the case of **3f—h** was filtered off, washed with *tert*-butyl methyl ether and dried. In the case of compound **3e**, the solvent from the reaction mixture was evaporated *in vacuo* to dryness, and the residue was washed with water, crystallized from ethanol, and dried.

1-(*4-R*-Phenyl)carbamoylnaphtho[2,1-*e*]imidazo[5,1-*c*]-[1,2,4]triazines (5a—c) (general procedure). *p*-Toluidine, *p*-chloroaniline, or aniline (6.92 mmol), respectively, was added to a solution of carboxazide **5l** (1 g 3.46 mmol) in DMF (10 mL). The mixture was vigorously stirred for 8 h at 70 °C and then cooled, and the precipitate was filtered off, crystallized from DMF, washed with acetone, and dried.

1-Carbamoylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (5d). A mixture of carboxazide **5l** (1 g, 3.46 mmol) and aqueous ammonia (15 mL) was refluxed for 6 h and then cooled, and the yellow precipitate was filtered off, crystallized from DMF, washed with acetone, and dried.

1-Cyclohexylcarbamoylnaphtho[2,1-*e*]imidazo[5,1-*c*]-[1,2,4]triazine (5e). Cyclohexylamine (0.79 mL, 6.92 mmol) was added to a solution of carboxazide **5l** (1 g, 3.46 mmol) in DMF (10 mL), and the mixture was kept for 30 min at 70 °C, cooled, and treated with CCl_4 (10 mL). The yellow precipitate was filtered off, crystallized from a DMF—acetone mixture, and dried.

1-Methylcarbamoylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (5f) (see Refs 7,8). ***A.*** Methylamine (14.6 mL, 0.17 mol) was added to a solution of 1-ethoxycarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5i**) (1 g, 3.43 mmol) in DMF (10 mL). The reaction mixture was kept for 5 h at 100 °C and cooled, and the precipitate was filtered off, recrystallized from a DMF—ethanol mixture, and dried.

B. Methylamine (1.5 mL, 17.3 mmol) was added to a solution of carboxazide **5l** (1 g, 3.46 mmol) in DMF (10 mL), and the mixture was kept for 1 h at 70 °C, cooled, and treated with CCl_4 (10 mL). The yellow precipitate was filtered off, recrystallized from a DMF—ethanol mixture, and dried.

1-*R*-Naphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazines (5g,h) (general procedure). *p*-Toluenesulfonic acid (0.03 mmol) was added to a mixture of 4-*R*-5-(2-hydroxynaphthylazo)imidazole **3g,h** (3.23 mmol) and glacial AcOH (20 mL), the mixture was kept at 80—90 °C (see Table 1) and cooled, and the precipitate was filtered off, crystallized from DMF, washed with a slight amount of ether, and dried.

1-Hydrazinocarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*]-[1,2,4]triazine (5j). A mixture of 1-carbethoxynaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5i**) (1 g, 3.43 mmol), 60% hydrazine hydrate (2.85 mL, 34.2 mmol), and ethanol (15 mL) was refluxed on a water bath for 7 h and cooled, and the precipitate was filtered off, recrystallized from DMF, and dried.

1-Isopropylidenehydrazinocarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (5k). A mixture of 1-carbohydrazidonaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5j**) (1 g, 3.60 mmol), DMF (10 mL), and acetone (10 mL) was refluxed for 0.5—1 h and cooled, and the precipitate was filtered off, recrystallized from a DMF—acetone mixture, and dried.

1-Azidocarbonylnaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (5l). 1-Carbohydrazidonaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5j**) (1 g, 3.60 mmol) was added to a cooled (0 °C) mixture of concentrated HCl (1.5 mL, 18 mmol) and water (20 mL). At 0 °C, a cooled solution of $NaNO_2$ (0.75 g, 11 mmol) in water (10 mL) was added dropwise with vigorous stirring, and the mixture was stirred with cooling for 1.5—2 h. The yellow precipitate was filtered off, washed with a slight amount of cold water, and dried *in vacuo*.

1-Ethoxycarbonylaminonaphth[2,1-*e*]imidazo[5,1-*c*]-[1,2,4]triazine (5n). 1-Carboxazidonaphtho[2,1-*e*]imidazo[5,1-*c*][1,2,4]triazine (**5l**) (1 g, 3.46 mmol) was suspended in ethanol (20 mL), and the mixture was kept for 2 h at 60 °C with vigorous stirring, and cooled. The precipitate was crystallized from a DMF—ethanol mixture and dried.

This work was supported by the Russian Foundation for Basic Research (Project No. 04-03-96121a), the Council on Grants of Russian Federation President (program for the support of young Ph.D´s, grant MK 3014.2005.3), the Civil Research and Development Foundation (CRDF)

and the Ministry of Education and Science of the Russian Federation (joint grant Y3-C-05-15).

References

1. J. Vilarrassa and R. Granados, *J. Heterocycl. Chem*., 1974, **11**, 867.
2. S. Castillun and E. Melindez, *J. Heterocycl. Chem*., 1982, **19**, 61.
3. J. K. Horton and M. F. G. Stevens, *J. Chem. Soc., Perkin Trans. 1*, 1981, 1433.
4. E. V. Sadchikova, V. S. Mokrushin, *Izv. Akad. Nauk. Ser. Khim*., 2005, 348 [*Russ. Chem. Bull., Int. Ed*., 2005, **54**, 354].
5. V. S. Mokrushin and M. A. Bezmaternikh, *Mendeleev Commun*., 1998, 197.
6. M. A. Bezmaternykh, V. S. Mokrushin, and E. V. Sadchikova, *Khimiya Geterotsikl. Soedinen*., 2000, 540 [*Chem. Heterocycl. Compd*., 2000, 394 (Engl. Transl.)].
7. D. A. F. Langnel, J. Arrowsmith, and M. F. G. Stevens, *Arkivoc*, 2000, **1**, 421.
8. E. V. Sadchikova and V. S. Mokrushin, *Izv. Akad. Nauk. Ser. Khim*., 2003, 1516 [*Russ. Chem. Bull., Int. Ed*., 2003, **52**, 1600].

Received October 17, 2005;
in revised form June 20, 2006