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SYNTHESIS AND CHEMICAL TRANSFORMATIONS OF 6-AMINO-7-CHLORO-2-(2-HYDROXYPHENYL)-2*H*-BENZO-TRIAZOLE-4-CARBOXYLIC ACID DERIVATIVES

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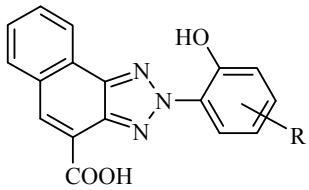
6-Amino-7-chloro-2-(2-hydroxyphenyl)-2H-benzotriazole-4-carboxylic acid and its analogs containing chlorine and nitro groups in the phenyl fragment have been synthesized. The special features of reduction and acetylation reactions with the obtained compounds have been studied. Methods have been developed for further chemical conversions which enable a large number of 2-(2-hydroxyphenyl)-2H-benzotriazole-4-carboxylic acid derivatives to be obtained, with the aim of studying the dependence of their luminescence and complex-forming properties on various functional substituents.

Keywords: 6-amino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid, *N*- and *O*-acetylation, oxidative cyclization, reductive dechlorination.

2-Phenyl-2*H*-benzotriazole derivatives are of high practical interest. In particular, alkyl-substituted 2-(2-hydroxyphenyl)-2*H*-benzotriazoles are effective UV absorbents and light stabilizers of polymeric materials and cosmetic compositions [1]. This special feature is caused in part by the existence of an intramolecular hydrogen bond between the *o*-hydroxyl of the phenyl nucleus and the azole fragment, the strength of which affects the absorption and emission wavelength to a significant degree, and is changed upon introduction of various substituents [2]. In addition, substituted 2-(2-hydroxyphenyl)-2*H*-benzotriazole derivatives possess ligand properties [3]. In similar compounds of the naphtho[1,2-*d*]triazole series the carboxyl group at the position 4 of the heteroaromatic fragment increases the stability of the coordinated compounds by forming an additional bond with the metal, which leads to a significant change in their electron absorption spectra [4].



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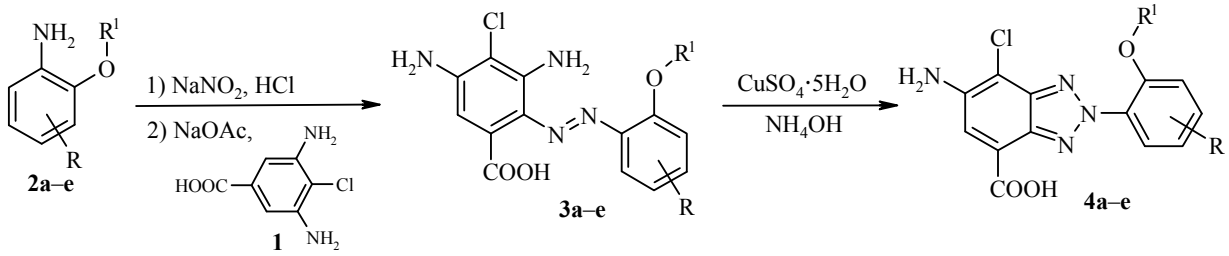
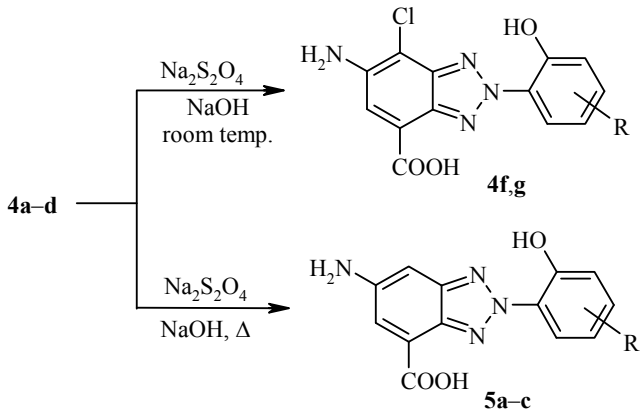
In connection with the above it seemed expedient to develop a method of synthesis for new derivatives of 6-amino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid. These compounds may be obtained by azocoupling of substituted *m*-phenylenediamine and *o*-benzoquinonediazide with subsequent oxidative cyclization of the corresponding azo compounds [5]. We have therefore selected the available 3,5-diamino-4-chlorobenzoic acid (**1**) as the azo component containing the required carboxyl group.

Diazotization of derivatives **2a-e** was carried out by the action of $NaNO_2$/HCl, and the diazo compounds obtained were coupled directly with 3,5-diamino-4-chlorobenzoic acid (**1**) in the presence of sodium acetate (Table 1). The synthesized azo compounds **3a-e** were oxidized with copper-ammonia reagent (solution of $CuSO_4$ in aqueous NH_3) to 2*H*-benzotriazole-4-carboxylic acids **4a-e**. To purify from copper compounds, the reaction mixture was treated with a solution of Na_2S and NaOH, and after the removal of solids the target compounds **4a-e** were isolated by acidification and purified by recrystallization.



a R = R^1 = H; **b** R = 5-NO_2, R^1 = H; **c** R = 4-NO_2, R^1 = H; **d** R = 5-Cl, R^1 = H; **e** R = H, R^1 = Me

Further modification included studying the reduction reaction of the synthesized compounds **4a-d**. Reduction of nitro compound **4b** was effected by the action of an excess of $Na_2S_2O_4$ in refluxing alkaline solution. Data of ^{1}H NMR spectra and LCMS (liquid chromatography-mass spectrometry) of the isolated product showed that along with nitro group reduction in these compounds a dechlorination also occurred, leading to the formation of a mixture of 6-amino-2-(5-amino-2-hydroxyphenyl)-7-chloro-2*H*-benzotriazole-4-carboxylic acid (**4f**) and 6-amino-2-(5-amino-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (**5b**) (Tables 1, 2). Derivative **5b** could not be obtained in pure form in spite of attempts to change the reaction conditions (duration, amount of reducing agent). Carrying out the reaction at room temperature eliminated dechlorination, and the sole reduction product was compound **4f**.



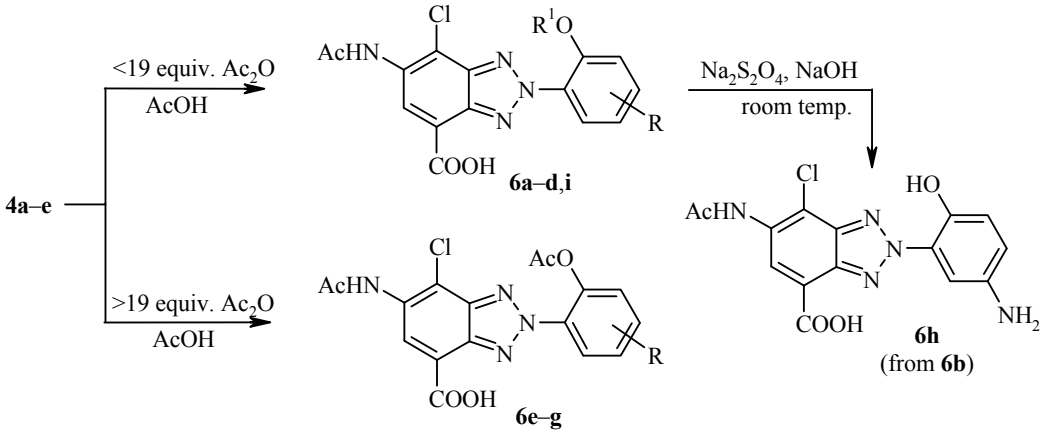
4 f R = 5-NH_2, **g** R = 4-NH_2; **5 a** R = H, **b** R = 5-NH_2, **c** R = 5-Cl

TABLE 1. Physicochemical Characteristics of the Obtained Compounds

Compound	Empirical formula	Found, % / Calculated, %			Mp, °C	Yield, %
		C	H	N		
3a	$C_{13}H_{11}ClN_4O_3$	51.07 / 50.91	3.59 / 3.62	18.36 / 18.27	215–217 (decomp., EtOH)	85
3b	$C_{13}H_{10}ClN_5O_5$	44.64 / 44.40	2.91 / 2.87	19.79 / 19.91	218–220 (decomp., EtOH)	93
3c	$C_{13}H_{10}ClN_5O_5$	44.31 / 44.40	2.83 / 2.87	20.13 / 19.91	250–253 (decomp., EtOH)	94
3d	$C_{13}H_{10}Cl_2N_4O_3$	45.70 / 45.77	2.98 / 2.95	16.45 / 16.42	234–236 (decomp., EtOH)	87
3e	$C_{14}H_{13}ClN_4O_3$	52.25 / 52.43	4.13 / 4.09	17.35 / 17.47	234–236 (EtOH)	87
4a	$C_{13}H_9ClN_4O_3$	51.19 / 51.25	3.00 / 2.98	18.51 / 18.39	298–300 (decomp., dioxane)	51
4b	$C_{13}H_8ClN_5O_5$	44.72 / 44.65	2.30 / 2.31	19.91 / 20.03	>310 (dioxane)	62
4c	$C_{13}H_8ClN_5O_5$	44.47 / 44.65	2.33 / 2.31	19.95 / 20.03	> 310 (THF)	52
4d	$C_{13}H_8Cl_2N_4O_3$	45.95 / 46.04	2.34 / 2.38	16.60 / 16.52	283–285 (decomp., EtOH)	65
4e	$C_{14}H_{11}ClN_4O_3$	52.71 / 52.76	3.46 / 3.48	17.63 / 17.58	260–262 (EtOH)	65
4f	$C_{13}H_{10}ClN_5O_3$	48.78 / 48.84	3.13 / 3.15	21.72 / 21.91	247–249 (decomp., dioxane)	37
4g	$C_{13}H_{10}ClN_5O_3$	48.91 / 48.84	3.14 / 3.15	21.93 / 21.91	262–264 (decomp., dioxane)	58
5a	$C_{13}H_{10}N_4O_3$	57.72 / 57.78	3.71 / 3.73	20.82 / 20.73	260–262 (decomp., EtOH)	52
5c	$C_{13}H_9ClN_4O_3$	51.36 / 51.25	3.01 / 2.98	18.34 / 18.39	286–289 (decomp., EtOH)	55
6a	$C_{15}H_{11}ClN_4O_4$	51.74 / 51.96	3.17 / 3.20	16.20 / 16.16	>310 (AcOH)	48
6b	$C_{15}H_{10}ClN_5O_6$	46.12 / 45.99	2.54 / 2.57	17.84 / 17.88	>310 (AcOH)	81
6c	$C_{15}H_{10}ClN_5O_6$	45.74 / 45.99	2.62 / 2.57	17.98 / 17.88	>310 (AcOH)	54
6d	$C_{15}H_{10}Cl_2N_4O_4$	47.41 / 47.27	2.67 / 2.64	14.62 / 14.70	>310 (AcOH)	21
6e	$C_{17}H_{13}ClN_4O_5$	52.61 / 52.52	3.40 / 3.37	14.35 / 14.41	232–234 (AcOH)	15
6f	$C_{17}H_{12}ClN_5O_7$	47.11 / 47.07	2.77 / 2.79	16.22 / 16.15	269–271 (AcOH)	44
6g	$C_{17}H_{12}Cl_2N_4O_5$	48.42 / 48.25	2.89 / 2.86	13.15 / 13.24	276–278 (AcOH)	50
6h	$C_{15}H_{12}ClN_5O_4$	49.86 / 49.80	3.31 / 3.34	19.41 / 19.36	277–278 (AcOH)	52
6i	$C_{16}H_{13}ClN_4O_4$	53.39 / 53.27	3.65 / 3.63	15.43 / 15.53	302–304 (AcOH)	60
7a	$C_{14}H_{11}ClN_4O_3$	52.81 / 52.76	3.45 / 3.48	17.73 / 17.58	233–235 (EtOH)	49
7b	$C_{14}H_{10}ClN_5O_5$	46.35 / 46.23	2.82 / 2.77	19.34 / 19.25	163–165 (decomp., EtOH)	70
7c	$C_{14}H_{10}ClN_5O_5$	46.15 / 46.23	2.74 / 2.77	19.34 / 19.25	292–294 (EtOAc)	73
7d	$C_{14}H_{10}Cl_2N_4O_3$	47.84 / 47.61	2.88 / 2.85	15.78 / 15.86	244–245 (EtOH)	39
7e	$C_{14}H_{12}ClN_5O_3$	50.35 / 50.39	3.61 / 3.62	20.91 / 20.98	257–260 (EtOAc)	46
8	$C_{14}H_{12}N_4O_3$	59.10 / 59.15	4.23 / 4.25	19.66 / 19.71	236–238 (EtOAc)	53

Amine **4g** was synthesized under analogous conditions at room temperature from nitro compound **4c**. Reduction of the derivative **4c** by refluxing the reaction mixture in the presence of $Na_2S_2O_4$ led to the formation of an inseparable mixture of amine **4g** and the dechlorination product, as in the case of derivative **4b**. Purposeful reductive dechlorination was carried out successfully in the case of 2*H*-benzotriazoles **4a**,**d**. The compounds obtained **5a**,**c** were isolated and characterized spectrally, and it was established by this that replacement of chlorine by a hydrogen atom in the dichloro-substituted compound **4d** occurred only in the benzotriazole ring.

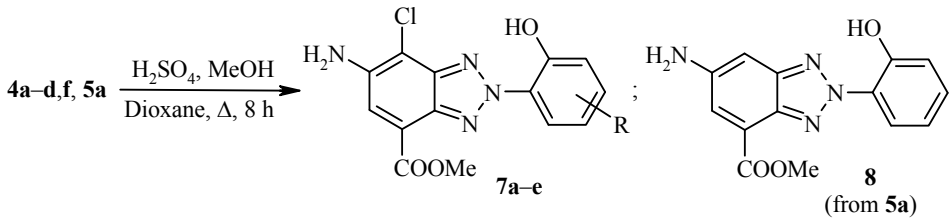
Acetylation of compounds **4a-d**, containing free amino and hydroxyl groups, was carried out with acetic anhydride in refluxing acetic acid. With the aid of electronic, IR, and ^{1}H NMR spectra it was found that both *N*- and *O*-acetylation was possible for compounds of this series. The former proceeds fairly readily, but the preparation of the diacetylated product required the presence of at least a 19-fold excess of acetic anhydride. After allowing for these considerations, compounds **6a-g** were synthesized.



6 a,**e**,**i** R = H, **b** R = 5-NO_2, **c**,**f** R = 4-NO_2, **d**,**g** R = 5-Cl; **6a–d** R^1 = H, **i** R^1 = Me

Only the *N*-acetylation product **6b** was formed from compound **4b** with a 19-fold excess of acetic anhydride, due to the significantly decreased nucleophilicity of aromatic hydroxyl group in *para* position relative to a nitro group. Data of IR and ^{1}H NMR spectra (Table 2) were in full agreement with the structures of the represented compounds. In the ^{1}H NMR spectra of the diacylated compounds **6e-g** two singlets were observed at high field corresponding to the acetyl group protons, while in the spectra of compounds **6a-d** only one singlet was present. In the IR spectra of the diacetylated derivatives a band was observed at 1780 cm^{-1} for the ester group C=O bond stretching vibrations. Acetylation of hydroxyl group in the compound **6a** (transition to compound **6e**) was accompanied by a hypsochromic shift of the electronic absorption spectrum long wave maximum by 25 nm, which resulted from the disappearance of the intramolecular hydrogen bond.

Nitro compound **6b**, containing an acetylamino group in the position 6, was reduced without heating by the procedure for synthesizing compound **4f**, giving 6-acetylamino-7-chloro-2-(5-amino-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (**6h**). In the course of this reaction the chlorine atom and acetyl function in the molecule were retained.



7 a R = H, **b** R = 5-NO_2, **c** R = 4-NO_2, **d** R = 5-Cl, **e** R = 5-NH_2

TABLE 2. Spectral Characteristics of the Synthesized Compounds

Compound	UV spectrum, λ_{abs}, nm (ε, l·mol^{-1}·cm^{-1})	IR spectrum, ν, cm^{-1}	^{1}H NMR spectrum, δ, ppm (J, Hz)
1	2	3	4
3a	460 (19370)	3425, 3350 (NH_2), 1700 (C=O)	6.67 (1H, s, H-5); 6.91-6.96 (2H, m, H-3',5'); 7.20 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-4'); 7.58 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 8.05 (2H, br. s, 5-NH_2); 11.00 (1H, br. s, OH)
3b	467 (23290)	3475, 3465, 3400 (NH_2), 1705 C=O), 1505, 1320 (NO_2)	6.61-6.65 (3H, m, H-5, 3-NH_2); 7.12 (1H, d, J = 8.8, H-3'); 8.06 (1H, dd, ^3J = 8.8, ^4J = 2.2, H-4'); 8.22 (2H, br. s, 5-NH_2); 8.42 (1H, d, J = 2.2, H-6'); 12.00 (2H, br. s, OH, COOH)
3c	505 (31080)	3465, 3455, 3390 (NH_2), 1710 (C=O), 1530, 1350 (NO_2)	6.66 (1H, s, H-5); 6.75 (2H, s, 3-NH_2); 7.67 (1H, dd, ^3J = 8.2, ^4J = 1.5, H-5'); 7.74-7.77 (2H, m, H-3',6'); 8.41 (2H, br. s, 5-NH_2); 11.80 (1H, br. s, OH)
3d	470 (23890)	3475, 3400 (NH_2), 1705 (C=O)	6.55-6.57 (3H, m, H-5, 3-NH_2); 6.97 (1H, d, J = 8.8, H-3'); 7.20 (1H, dd, ^3J = 8.8, ^4J = 2.0, H-4'); 7.57 (1H, d, J = 2.0, H-6'); 7.90 (1H, s, H-5); 8.13 (2H, br. s, 5-NH_2); 11.75 (1H, br. s, OH)
3e	470 (23680)	3390, 3320 (NH_2), 1695 (C=O)	3.92 (3H, s, OCH_3); 6.45 (2H, s, 3-NH_2); 6.54 (1H, s, H-5); 7.01 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.19 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); 7.34 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-4'); 7.45 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 8.20 (2H, br. s, 5-NH_2)
4a	390 (12640)	3465, 3390 (NH_2), 1700 (C=O)	6.03 (2H, s, NH_2); 7.05 (1H, dt, ^3J = 7.4, ^4J = 1.5, H-5'); 7.16 (1H, dd, ^3J = 7.4, ^4J = 1.5, H-3'); 7.39 (1H, dt, ^3J = 7.4, ^4J = 1.5, H-4'); 7.82 (1H, s, H-5); 7.95 (1H, dd, ^3J = 7.4, ^4J = 1.5, H-6')
4b	400 (13170)	3475, 3400 (NH_2), 1695 (C=O), 1560, 1350 (NO_2)	6.13 (2H, s, NH_2); 7.33 (1H, d, J = 7.3, H-3'); 7.92 (1H, s, H-5); 8.26 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 8.74 (1H, d, J = 1.5, H-6'); 12.20 (1H, br. s, COOH)
4c	420 (13820)	3455, 3380 (NH_2), 1705 (C=O), 1530, 1350 (NO_2)	6.23 (2H, s, NH_2); 7.89-7.95 (3H, m, H-5,3',5'); 8.17 (1H, d, J = 8.6, H-6'); 11.55 (1H, br. s, OH); 13.20 (1H, br. s, COOH)
4d	398 (11230)	3460, 3390 (NH_2), 1700 (C=O)	6.21 (2H, s, NH_2); 7.18 (1H, d, J = 8.8, H-3'); 7.48 (1H, dd, ^3J = 8.8, ^4J = 2.2, H-4'); 7.87 (1H, d, J = 2.2, H-6'); 7.90 (1H, s, H-5); 10.92 (1H, br. s, OH)
4e	365 (7570)	3420, 3355 (NH_2), 1690 (C=O)	3.80 (3H, s, OCH_3); 5.92 (2H, s, NH_2) 7.14 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.31 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); 7.56-7.60 (2H, m, H-4',6'); 7.78 (1H, s, H-5); 12.50 (1H, br. s, COOH)
4f	410 (11850)	3415, 3340 (NH_2), 1700 (C=O)	6.15 (2H, s, 6-NH_2); 6.79 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 6.94 (1H, d, J = 7.3, H-3'); 7.44 (1H, d, J = 1.5, H-6'); 7.89 (1H, s, H-5); 10.28 (1H, s, OH)
4g	405 (13110)	3440, 3430, 3365 (NH_2), 1705 (C=O)	5.60 (2H, br. s, 4'-NH_2); 5.98 (2H, s, 6-NH_2); 6.25-6.28 (2H, m, H-3',5'); 7.64 (1H, d, J = 8.1, H-6'); 7.81 (1H, s, H-5); 10.70 (1H, br. s, OH)
5a	385 (9750)	3475, 3400 (NH_2), 1700 (C=O)	5.85 (2H, br. s, NH_2); 6.94 (1H, d, J = 1.5, H-7); 7.00 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.20 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); 7.34 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-4'); 7.71 (1H, d, J = 1.5, H-5); 7.93 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 12.00 (1H, br. s, COOH)

TABLE 2 (continued)

1	2	3	4
5c	385 (9610)	3475, 3400 (NH_2), 1705 (C=O)	6.21 (2H, s, NH_2); 6.94 (1H, d, *J* = 1.5, H-7); 7.22 (1H, d, *J* = 7.3, H-3'); 7.33 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 7.68 (1H, d, *J* = 1.5, H-5); 7.91 (1H, d, *J* = 1.5, H-6')
6a	350 (15600)	3295 (N-H), 1690 (C=O)	2.18 (3H, s, CH_3); 7.07 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.18 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); 7.47 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-4'); 7.79 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 8.44 (1H, s, H-5); 10.01 (1H, s, NH); 10.59 (1H, s, OH)
6b	345 (15470)	3390 (N-H), 1710, 1695 (C=O), 1560, 1350 (NO_2)	2.19 (3H, s, CH_3); 7.36 (1H, d, *J* = 8.1, H-3'); 8.33 (1H, dd, ^3J = 8.1, ^4J = 2.2, H-4'); 8.48 (1H, s, H-5); 8.64 (1H, d, *J* = 2.2, H-6'); 9.99 (1H, s, NH); 12.15 (1H, br. s, COOH)
6c	370 (19250)	3350 (N-H), 1715, 1700 (C=O), 1530, 1350 (NO_2)	2.20 (3H, s, CH_3); 7.90 (1H, dd, ^3J = 8.8, ^4J = 2.2, H-5'); 7.97 (1H, d, ^4J = 2.2, H-3'); 8.13 (1H, d, ^3J = 8.8, H-6'); 8.50 (1H, s, H-5); 9.85 (1H, s, NH); 11.45 (2H, br. s, OH, COOH)
6d	360 (16220)	3370 (N-H), 1715, 1700 (C=O)	2.18 (3H, s, CH_3); 7.20 (1H, d, *J* = 8.8, H-3'); 7.53 (1H, dd, ^3J = 8.8, ^4J = 2.2, H-4'); 7.85 (1H, d, *J* = 2.2, H-6'); 8.44 (1H, s, H-5); 10.01 (1H, s, NH); 10.79 (1H, br. s, OH); 13.10 (1H, br. s, COOH)
6e	320 (18620)	3310 (N-H), 1775, 1695 (C=O)	2.18 (3H, s, $NCOCH_3$); 2.30 (3H, s, $OCOCH_3$); 7.47-7.68 (3H, m, H-3',4',5'); 8.20 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 8.45 (1H, s, H-5); 10.08 (1H, s, NH); 13.30 (1H, br. s, COOH)
6f	335 (21150)	3360 (N-H), 1775, 1715, 1695 (C=O), 1530, 1350 (NO_2)	2.19 (3H, s, $NCOCH_3$); 2.39 (3H, s, $OCOCH_3$); 8.42-8.56 (4H, m, H-5,3',5',6'); 10.08 (1H, s, NH); 12.70 (1H, br. s, COOH)
6g	320 (14360)	3380 (N-H), 1780, 1710, 1695 (C=O)	2.18 (3H, s, $NCOCH_3$); 2.31 (3H, s, $OCOCH_3$); 7.53 (1H, d, *J* = 8.8, H-3'); 7.74 (1H, dd, ^3J = 8.8, ^4J = 2.2, H-4'); 8.24 (1H, d, *J* = 2.2, H-6'); 8.46 (1H, s, H-5); 10.01 (1H, s, NH); 11.60 (1H, br. s, COOH)
6h	398 (6160)	3415, 3340 (NH_2), 3325 (N-H), 1710, 1700 (C=O)	2.18 (3H, s, CH_3); 6.83 (1H, dd, ^3J = 8.1, ^4J = 2.2, H-4'); 6.96 (1H, d, *J* = 8.1, H-3'); 7.32 (1H, d, *J* = 2.2, H-6'); 8.43 (1H, s, H-5); 10.00 (1H, s, 6-NH); 10.04 (1H, s, OH)
6i	310 (14200)	3290 (N-H), 1690, 1670 (C=O)	2.17 (3H, s, $COCH_3$); 3.81 (3H, s, 2'-OCH_3); 7.19 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.37 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); 7.64-7.68 (2H, m, H-4',6'); 8.40 (1H, s, H-5); 10.01 (1H, s, NH); 12.85 (1H, br. s, COOH)
7a	400 (13600)	3475, 3400 (NH_2), 1710 (C=O)	3.93 (3H, s, CH_3); 6.15 (2H, br. s, NH_2); 7.05 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-4'); 7.16 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-3'); .42 (1H, dt, ^3J = 7.3, ^4J = 1.5, H-5'); 7.80 (1H, s, H-5); 7.93 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 10.68 (1H, s, OH)
7b	403 (7930)	3475, 3400 (NH_2), 1720 (C=O), 1560, 1350 (NO_2)	3.95 (3H, s, CH_3); 7.33 (1H, d, *J* = 7.3, H-3'); 7.94 (1H, s, H-5); 8.28 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 8.67 (1H, d, *J* = 1.5, H-6')
7c	420 (14830)	3460, 3390 (NH_2), 1715 (C=O), 1530, 1350 (NO_2)	3.93 (3H, s, CH_3); 6.27 (2H, s, NH_2); 7.87-7.95 (3H, m, H-5,3',5'); 8.11 (1H, d, *J* = 8.0, H-6'); 11.47 (1H, s, OH)

TABLE 2 (continued)

1	2	3	4
7d	405 (14260)	3450, 3375 (NH_2), 1710 (C=O)	3.93 (3H, s, CH_3); 6.20 (2H, s, NH_2); 7.17 (1H, d, J = 7.3, H-3'); 7.47 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 7.86 (1H, s, H-5); 7.93 (1H, d, J = 1.5, H-6'); 10.84 (1H, s, OH)
7e	412 (12120)	3425, 3350 (NH_2), 1715 (C=O)	3.94 (3H, s, CH_3); 5.05 (2H, br. s, 5'-NH_2); 6.21 (2H, s, 6-NH_2); 6.68 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-4'); 6.88 (1H, d, J = 7.3, H-3'); 7.29 (1H, s, H-5); 7.93 (1H, d, J = 1.5, H-6'); 10.01 (1H, s, OH)
8	400 (12600)	3475, 3400 (NH_2), 1710 (C=O)	3.94 (3H, s, CH_3); 5.85 (2H, br. s, NH_2); 7.04-7.08 (2H, m, H-7,5'); 7.15 (1H, dd, ^3J = 7.3, ^4J = 2.2, H-3'); 7.38 (1H, dt, ^3J = 7.3, ^4J = 2.2, H-4'); 7.78 (1H, d, J = 2.2, H-5); 8.00 (1H, dd, ^3J = 7.3, ^4J = 1.5, H-6'); 11.03 (1H, s, OH)

For further assessment of the hydroxyl and carboxyl group effects on the selectivity of complex formation, and on spectral differences of the initial ligand and complexes, 2*H*-benzotriazole derivatives containing a 2-methoxy group in the phenyl ring (compounds **4e** and **6i**) and a 4-methoxycarbonyl group in the benzotriazole fragment (compounds **7a-e** and **8**) were also synthesized.

A series of new substituted 6-amino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid derivatives has therefore been synthesized, aided by procedures developed for selective reduction, acetylation, and reductive dechlorination.

EXPERIMENTAL

The IR spectra were recorded on a Specord M80 spectrometer in nujol. Electronic absorption spectra were recorded on a Specord M400 spectrophotometer in ethanol. ^{1}H NMR spectra were recorded on a Bruker AM-300 instrument (300 MHz) in DMSO-d_6, internal standard was TMS. Liquid chromatography-mass spectra (LCMS) were recorded on a Surveyor MSQ spectrometer, column was Phenomenex Onyx Monolithic C18 25×4.6 mm, eluent 0.1% HCOOH–MeCN, flow rate 1.5 ml/min, method of ionization APCI. Elemental analysis was carried out on a vario Micro cube instrument. Melting points were determined on a PTP-M instrument. A check on the progress of reactions and the purity of the obtained compounds was effected by TLC on Sorbfil plates (silica gel CTX-1A, UV-254).

3,5-Diamino-4-chlorobenzoic Acid (1). A solution of NaOH (13.20 g, 0.33 mol) in H_2O (90 ml) was added dropwise to a boiling solution of 3,5-diamino-4-chlorobenzoic acid isobutyl ester (29.12 g, 0.12 mol) in ethanol (100 ml). The obtained mixture was left for 1 h, then cooled, and acidified with conc. HCl to pH 7. The precipitated solid was filtered off, washed with water and dried at 50°C. Yield 20.38 g (91%). Pink solid substance; mp > 300°C. IR spectrum, ν, cm^{-1}: 3375, 3300 (NH_2), 1695 (C=O). ^{1}H NMR spectrum, δ, ppm: 6.67 (2H, s, H-2,6); 4.42 (4H, br. s, 2NH_2). Found, %: C 45.14; H 3.75; N 15.07. $C_7H_7ClN_2O_2$. Calculated, %: C 45.06; H 3.78; N 15.01.

3,5-Diamino-4-chloro-2-(2-hydroxyphenyl)diazenylbenzoic Acid (3a). A solution of *o*-aminophenol (**2a**) (4.47 g, 29 mmol) in H_2O (83.0 ml) and conc. HCl (7.3 ml) was diazotized with a solution of $NaNO_2$ (2.07 g, 30 mmol) in H_2O (5.0 ml) for 1 h 15 min at a temperature no higher than 10°C. The completion of the reaction was determined with the aid of starch-iodide paper. The solution of diazonium salt obtained was added over 15 min to a solution of 3,5-diamino-4-chlorobenzoic acid (**1**) (5.41 g, 29 mmol) in EtOH (200 ml) and H_2O

(155 ml), after which a concentrated solution of NaOAc was added to pH 6. The reaction mixture was stirred for 3.5 h. The precipitated solid was filtered off, washed with water, and dried at 50°C. A solid substance of red color was obtained.

3,5-Diamino-4-chloro-2-(2-hydroxy-5-nitrophenylazo)benzoic Acid (3b), **3,5-diamino-4-chloro-2-(2-hydroxy-4-nitrophenylazo)benzoic acid (3c)**, **3,5-diamino-4-chloro-2-(5-chloro-2-hydroxyphenylazo)benzoic acid (3d)**, and **3,5-diamino-4-chloro-2-(2-methoxyphenylazo)benzoic acid (3e)** were obtained analogously. All azo compounds were red, solid substances.

6-Amino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic Acid (4a). A solution of copper-ammonium reagent, obtained from $CuSO_4 \cdot 5H_2O$ (20.97 g, 84 mmol), 25% aqueous NH_3 (75 ml), and H_2O (35 ml), was added dropwise to a refluxing solution of azo compound **3a** (7.36 g, 24 mmol) in a mixture of 2-PrOH (50 ml) and 25% aqueous NH_3 (150 ml). The reaction mixture was stirred for 10 h, then cooled, and acidified to pH 6 with 10% HCl. The precipitated solid was filtered off, suspended in a solution of NaOH (2.52 g, 63 mmol) and $Na_2S \cdot 9H_2O$ (8.64 g, 36 mmol) in H_2O (900 ml) and stirred for 1 h at 90°C. The mixture was filtered, the filtrate cooled, and acidified with 10% HCl to pH 5.5. The precipitated solid was filtered off, washed with water, and dried at 50°C. After recrystallization from dioxane the product was obtained as a yellow, solid substance.

6-Amino-7-chloro-2-(2-hydroxy-5-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid (4b) (reaction time 20 h), **6-amino-7-chloro-2-(2-hydroxy-4-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid (4c)** (reaction time 30 h, NaOH solution was used for purification from copper ions), **6-amino-7-chloro-2-(5-chloro-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (4d)** (reaction time 3 h), **6-amino-7-chloro-2-(2-methoxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (4e)** (reaction time 5 h) were obtained analogously. The derivatives were solid substances of yellow (compounds **4b**,**e**), orange (**4c**), or beige color (**4d**).

6-Amino-2-(5-amino-2-hydroxyphenyl)-7-chloro-2*H*-benzotriazole-4-carboxylic Acid (4f). A solution of $Na_2S_2O_4$ (7.83 g, 45 mmol) in H_2O (30 ml) was added dropwise to a solution of compound **4b** (1.05 g, 3 mmol) and NaOH (3.00 g, 75 mmol) in H_2O (50 ml). The reaction mixture was stirred at room temperature for 4.5 h, then acidified with 10% HCl to pH 6. The precipitated solid was filtered off, washed with water, and dried at 50°C. After extraction with acetone in a Soxhlet apparatus, the organic layer was evaporated, and a yellow, solid substance was obtained.

6-Amino-2-(4-amino-2-hydroxyphenyl)-7-chloro-2*H*-benzotriazole-4-carboxylic acid (4g) (from compound **4c**) and acid **6h** (from compound **6b**) were obtained analogously at room temperature. On refluxing the reaction mixture for 4.5 h **6-amino-2-(2-hydroxyphenyl-2*H*-benzotriazole-4-carboxylic acid (5a)** (from compound **4a**) and **6-amino-2-(5-chloro-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (5c)** (from compound **4d**) were obtained. All the compounds were yellow, solid substances.

On refluxing the reaction mixture, compound **4b** gave a mixture of compound **4f** and **6-amino-2-(5-amino-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (5b).** Mp 250-290°C (decomp.). ^{1}H NMR spectrum, δ, ppm (*J*, Hz) (ratio **4f** : **5b** was 1:2): 5.74 (1.33H, br. s, NH_2 (**5b**)); 6.05 (0.66H, s, NH_2 (**4f**)); 6.77-6.84 (1H, m, H-4' (**4f** + **5b**)); 6.92-6.97 (1.66H, m, H-3' (**4f** + **5b**), H-7 (**5b**)); 7.43-7.46 (1H m, H-6' (**4f** + **5b**)); 7.72 (0.66H, d, *J* = 1.6, H-5 (**5b**)); 7.89 (0.33H, s, H-5 (**4f**)); 10.32 (0.33H, s, OH (**4f**)); 10.60 (0.66H, s, OH (**5b**)). Chromatography with mass spectral detector gave *m/z* (τ, min): 286 $[M+H]^+$ (1.40) (**5b**), 320 $[M+H]^+$ (1.51) (**4f**).

6-Acetylamino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic Acid (6a). Ac_2O (1.9 ml, 20 mmol, 4 equiv.) was added dropwise to a suspension of the benzotriazole **4a** (1.52 g, 5 mmol) in glacial AcOH (100 ml). The reaction mixture was refluxed for 7.5 h, diluted with cold water (100 ml), and stirred for a further 20 min. The precipitated solid was filtered off, and dried under reduced pressure. After recrystallization from glacial acetic acid, a yellowish, solid substance was obtained.

6-Acetylamino-7-chloro-2-(2-hydroxy-4-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid (6c) and **6-acetylamino-7-chloro-2-(5-chloro-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (6d)** were obtained analogously from compounds **4c**,**d** using 8 equiv. Ac_2O. On using 19 equiv. Ac_2O, **6-acetylamino-**

7-chloro-2-(2-hydroxy-5-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid (6b) and **6-acetylamino-7-chloro-2-(2-methoxyphenyl)-2*H*-benzotriazole-4-carboxylic acid (6i)** were obtained from compounds **4b**,**e**. On using 19 equiv. Ac_2O, the diacetylated product **2-(2-acetoxyphenyl)-6-acetylamino-7-chloro-2*H*-benzotriazole-4-carboxylic acid (6e)** was obtained from compound **4a**. On using 50 equiv. Ac_2O, **2-(2-acetoxy-4-nitrophenyl)-6-acetylamino-7-chloro-2*H*-benzotriazole-4-carboxylic acid (6f)** and **2-(2-acetoxy-5-chlorophenyl)-6-acetylamino-7-chloro-2*H*-benzotriazole-4-carboxylic acid (6g)** were obtained from compounds **4c**,**d**. **6-Acetylamino-2-(5-amino-2-hydroxyphenyl)-7-chloro-2*H*-benzotriazole-4-carboxylic acid (6h)** was obtained by treating nitro derivative **6b** with NaOH and $Na_2S_2O_4$ at room temperature by the procedure for obtaining compound **4f**. All the acetyl derivatives were beige (compounds **6a**,**d**-**i**) or yellowish (compounds **6b**,**c**) solid substances.

6-Amino-7-chloro-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic Acid Methyl Ester (7a). 96% H_2SO_4 (1 ml) was added dropwise to a suspension of acid **4a** (0.91 g, 3 mmol) in dioxane (30 ml) and methanol (25 ml). The reaction mixture was refluxed for 8 h, then cooled. The precipitated solid was filtered off and dried at reduced pressure. After recrystallization from EtOH, a greenish-yellow solid substance was obtained.

6-Amino-7-chloro-2-(2-hydroxy-5-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid methyl ester (7b), **6-amino-7-chloro-2-(2-hydroxy-4-nitrophenyl)-2*H*-benzotriazole-4-carboxylic acid methyl ester (7c)**, **6-amino-7-chloro-2-(5-chloro-2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic acid methyl ester (7d)**, and **6-amino-2-(2-hydroxyphenyl)-2*H*-benzotriazole-4-carboxylic Acid (8)** were obtained analogously. All esters were yellow, solid substances.

The synthesis of **6-amino-2-(5-amino-2-hydroxyphenyl)-7-chloro-2*H*-benzotriazole-4-carboxylic acid methyl ester (7e)** was carried out in an analogous manner, after which 25% aqueous NH_3 was added dropwise to the obtained suspension to pH 7. The solid was filtered off and dried in vacuum. An orange, solid substance was obtained.

REFERENCES

1. G. Woessner, G. Goeller, J. Rieker, H. Hoier, J. J. Stezowski, E. Daltrozzo, M. Neurieter, and H. E. A. Kramer, *J. Phys. Chem. B*, **89**, 3629 (1985).
2. B. M. Krasovitskii and B. M. Bolotin, *Organic Luminophores* [in Russian], Khimiya, Moscow (1984), p. 100.
3. T. Carofiglio, E. Solari, C. Floriani, A. Chiesi-Villa, and C. Rizzoli, *Polyhedron*, **15**, 4435 (1996).
4. E. Steiner and G. Schetty, *Helv. Chim. Acta*, **52**, 380 (1969).
5. M. P. Schmidt and A. Hagenbocker, *Ber. Dtsch. Chem. Ges*., *A*/*B*, **54**, 2191 (1921).