Three-component synthesis of 4-amino-2-aryl-2*H*-pyrimido-[1,2-*b*][1,3]benzazole-3-carbonitriles and 4*H*-pyrimido-[2,1-*b*][1,3]benzazoles in the presence of magnesium oxide and 12-tungstophosphoric acid as catalysts*

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A simple and convenient approach was suggested for the synthesis of 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*][1,3]benzimidazole-3-carbonitriles or -benzothiazole-3-carbonitriles through a three-component reaction of 2-aminobenzimidazole or 2-aminobenzothiazole, aldehyde, and malononitrile in the presence of magnesium oxide (MgO) and 12-tungstophosphoric acid as catalysts. Three-component reactions of aldehyde, β-ketoester, and 2-aminobenzimidazole or 2-aminobenzothiazole with the formation of 4*H*-pyrimido[2,1-*b*]benzimidazole or 4*H*-pyrimido[2,1-*b*]benzothiazole derivatives, respectively, were also studied. These approaches have the advantage of high yields, rapid and pure course of the reactions, as well as the use of cheap and available catalysts.

Key words: three-component reaction, 4*H*-pyrimido[2,1-*b*]benzimidazole, magnesium oxide, 12-tungstophosphoric acid.

Polyfunctional heterocycles are principal structural fragments of many medicines.[1,2] That is why, much attention is paid to their synthesis. Earlier, it was found[3,4] that pyrimidines fused to five-membered aromatic heterocycles containing two heteroatoms (such as benzimidazoles or benzothiazoles) possess interesting pharmacological properties. These compounds are characterized by a wide range of biological and pharmacological activity due to the presence in their structure of a "fold" passing through the nitrogen and sulfur atoms, which is believed to be one of the structural features responsible for their activity.[5,6] Analysis of literature data showed that there are only several works[7—10] devoted to the synthesis of pyrimidobenzimidazoles and pyrimidobenzothiazoles. There are three electron-enriched positions in 2-aminobenzimidazole (**1a**) or 2-aminobenzothiazole (**1b**): the nitrogen and sulfur atoms. Reactions of these compounds with electrophiles can take place either at exocyclic or endocyclic nitrogen atom, depending on the nature of the electrophile and reaction conditions.[11,12] Nucleophilic addition of 2-aminobenzothiazole to acetylenic esters **I** with subsequent cyclization leads to 2*H*-pyrimido[2,1-*b*]benzothiazol-2-one derivatives **II**. In this case, the endocyclic nitrogen atom of 2-aminobenzothiazole **1b** was found to be the most active.[13] However, addition of 2-aminobenzothiazole **1b** to bis(methylthio)methylenemalononitrile (**IIIa**) or ethyl 2-cyano-3,3-bis(methylthio)acrylate (**IIIb**) gives 3-cyano-4-imino-2-methylthio-4*H*-pyrimido[2,1-*b*][1,3]benzothiazole (**IVa**) and 3-cyano-2-methylthio-4*H*-pyrimido-[2,1-*b*][1,3]benzothiazol-4-one (**IVb**), respectively, *i.e.*, the exocyclic nitrogen atom is the most active in these reactions (Scheme 1).[14,15]

Dihydropyrimidine derivatives frequently exhibit valuable therapeutic and medicinal properties.[16,17] In particular, dihydropyrimidine derivatives, *viz.*, benzo[4,5]imidazo[1,2-*a*]pyrimidines, because of their biological activity are widely used as antineoplastics[18] and protein-kinase inhibitors.[19] These agents were synthesized by the Knoevenagel reaction between an aldehyde and a β-ketoester.[20] It should be noted that the indicated compounds were obtained by a three-component reaction. Despite simplicity, the known methods have a number of disadvantages, such as low yields, the use of toxic, expensive, and environmentally unfriendly solvents.[21—24] The disadvantages of the already existing methods prompted us to search for alternative approaches to the synthesis of 4*H*-pyrimido[2,1-*b*]benzimidazole and 4*H*-pyrimido[2,1-*b*]benzothiazole derivatives. We have developed three-component reactions of malononitrile or ethyl cyanoacetate with aldehydes and 1,3-binucleophiles, such as amidines,[25—27]

* Dedicated to the memory of Alirez Alfzalipur, the founder of the University of Kerman, in connection with the 100th anniversary of his birth.

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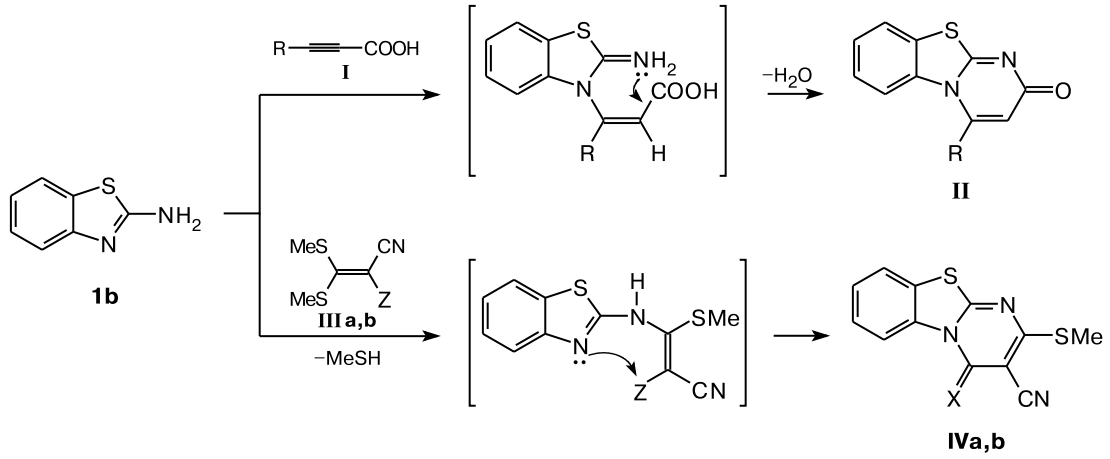
Scheme 1



Z = CN (**IIIa**), CO_2Et (**IIIb**); X = NH (**IVa**), O (**IVb**)

α-hydroxy- or α-amino-substituted activated C—H-acids,[28] α-oxohydrazones,[29] 3-alkyl-1-phenyl-2-pyrazolin-5-ones.[30]

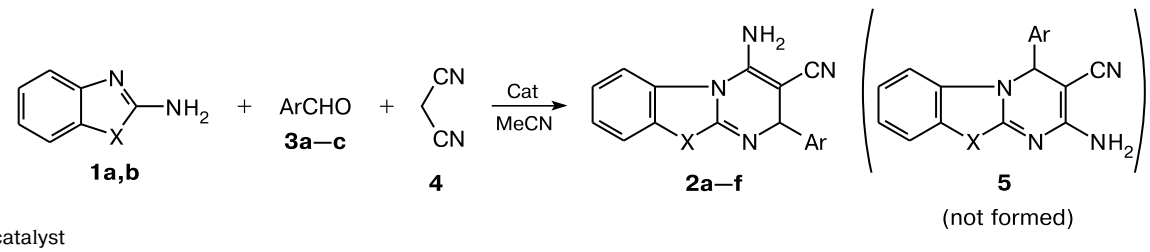
Results and Discussion

In the present work, we developed an efficient three-component one-pot method for the preparation of 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*][1,3](benzimidazole or benzothiazole)-3-carbonitriles and triheterocyclic 4*H*-pyrimido[2,1-*b*]benzazoles by the condensation of 2-aminobenzimidazole (**1a**) or 2-aminobenzothiazole (**1b**) with aldehydes and malononitrile or β-ketoester, respectively, in the presence of catalysts, *viz.*, MgO or 12-tungstophosphoric acid (PW). These heterogeneous catalysts can be easily regenerated from the reaction mixture by filtration and reused after activation. This is their advantage over common homogeneous catalysts. Magnesium oxide is a universal compound used as a heterogeneous basic catalyst for a number of the base-catalyzed organic reactions, as well as an additive in production of refractory materials, dyes, and superconductors.[31]

The target compounds, 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*]benzimidazole-3-carbonitriles or -benzothiazole-3-carbonitriles[32] **2a—f** were obtained by a three-component the reaction of 2-aminobenzimidazole **1a** or 2-aminobenzothiazole **1b**, aldehydes **3a—c**, and malononitrile (**4**) in the presence of catalysts, magnesium oxide and PW, in excellent yields (Scheme 2). These reactions were carried out in the presence of two forms of magnesium oxide crystals: commercial MgO (CM-MgO) and MgO with highly developed surface (HSA-MgO). It was found that HSA-MgO is more active than CM-MgO. We also used PW in the presence of a catalytic amount of triethylamine as a highly efficient heterogeneous catalyst. The experimental results are given in Table 1.

Heteropolyacids (HPA) are stronger acids than homogeneous acid catalysts, such as sulfuric acid or ion-exchange resins. As catalysts, they have a number of advantages, which make them economically and environmentally more preferable. The use of HPA as heterogeneous acid catalysts is important for the development of "green" catalysts, since they make it possible to avoid pollution of environment and prevent corrosion unavoidable in conventional technologies.[33]

Scheme 2



Cat is catalyst
X = NH (**1a**), S (**1b**)

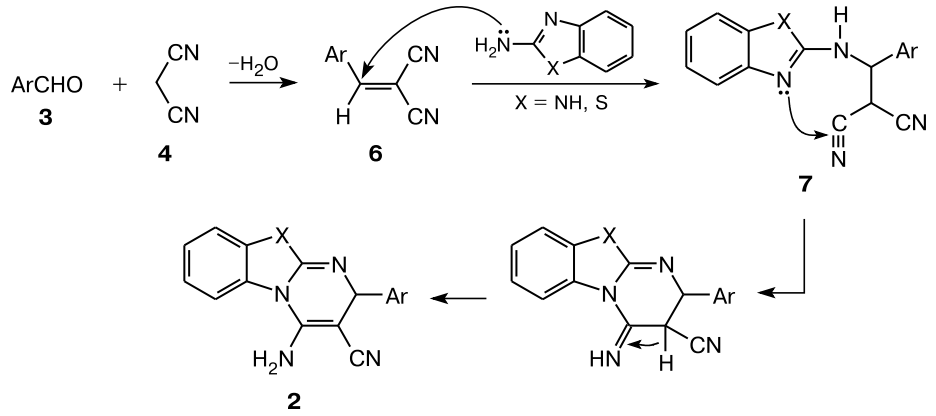
Table 1. Synthesis of compounds **2a**—**f** in the presence of catalysts

Compound	Ar	X	CM/HSA(MgO)		PW	
			t/min	Yield (%)	*t*/min	Yield (%)
2a	Ph	NH	90/10	80/92	15	91
2b	4-ClC_6H_4	NH	45/5	75/95	10	94
2c	2,4-$Cl_2C_6H_3$	NH	45/8	75/90	15	89
2d	Ph	S	60/12	70/91	22	91
2e	4-ClC_6H_4	S	45/8	80/93	15	92
2f	4-MeC_6H_4	S	75/12	80/90	18	90

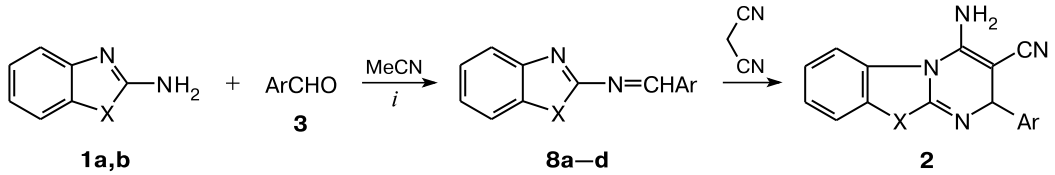
For one-pot reactions with sequential steps, usually called tandem or cascade reactions, it is essential to select such reaction conditions that the mixing the reagents and catalysts would trigger a required cascade of transformations. For example, benzylidenemalononitrile (**6**) containing an electron-poor carbon—carbon double bond, is formed quantitatively in the course of the rapid Knoevenagel reaction of malononitrile with the aromatic aldehyde. As we reported earlier,[27] this reaction readily occurs in the presence of MgO. In the second step, the exocyclic amino group of 2-aminobenzimidazole **1a** or 2-aminobenzothiazole **1b** attacks the electrophilic carbon—carbon double bond with the formation of the intermediate **7** (this differs from the mechanism for the preparation of compound **5**, where the endocyclic nitrogen atom of 2-aminobenzimidazole **1a** or 2-aminobenzothiazole **1b** reacts with the C=C double bond). Then, the endocyclic nitrogen atom acts as nucleophile and rapidly intramolecularly reacts with the CN fragment to form the final product **2**. We also studied a reaction between benzylidenemalononitrile **6** (obtained earlier by the reaction of benzaldehyde with malononitrile) and 2-aminobenzimidazole or 2-aminobenzothiazole in the presence of MgO with the highly developed surface, which gave 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*]benzimidazole-3-carbonitriles or -benzothiazole-3-carbonitriles **2** (Scheme 3).

It should be noted that the reaction is highly regioselective and leads only to one out of two possible isomers. The structure of products **2** was confirm by the study of the reaction of *N*-(benzimidazole- or 1,3-benzothiazol-2-yl)-*N*-(alkylidene)amines **8a**—**d** (obtained by the reaction of aldehydes with 2-aminobenzazoles) with malononitrile, which in the presence of MgO with highly developed surface led to the same 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*]-benzimidazole-3-carbonitrile or -benzothiazole-3-carbonitriles **2a**—**d** (Scheme 4).

Scheme 3



Scheme 4

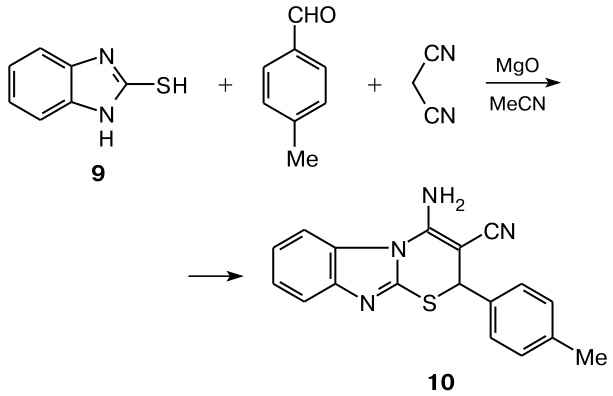


Ar = Ph (**8a**, **8c**), 4-ClC_6H_4 (**8b**, **8d**)
X = NH (**8a**, **8b**), S (**8c**, **8d**)

i. Reflux, 1 h.

4-Amino-2-(4-methylphenyl)-2*H*-[1,3]thiazino[3,2-*a*]-benzimidazole-3-carbonitrile (**10**) was similarly synthesized in excellent yield by the three-component reaction of benzimidazole-2-thiol (**9**), 4-methylbenzaldehyde, and malononitrile in the presence of MgO with highly developed surface as a highly efficient heterogeneous catalyst (Scheme 5).

Scheme 5



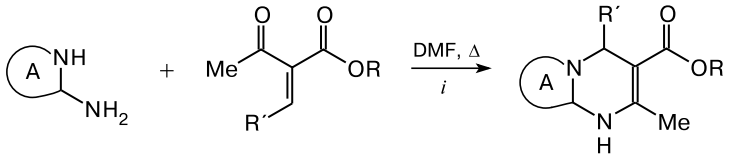
Bicyclic dihydropyrimidines (DHP), such as thiazolopyrimidines and imidazopyrimidines possessing a powerful vasorelaxant activity were obtained in two steps by the Biginelli reaction (Atwal modification) (Scheme 6). In this approach,[19] enones of the 3-benzylidene-2,4-pentanedione type undergo condensation with 2-aminothiazole or various aminoheterocycles like in the general procedure for the synthesis of monocyclic compounds by the Biginelli reaction.

To develop this strategy, we studied a three-component reactions of aldehyde, ethyl acetoacetate (or dimedone), and 2-aminobenzimidazole (or 2-aminobenzothiazole) leading to 4*H*-pyrimido[2,1-*b*]benzimidazole and 4*H*-pyrimido[2,1-*b*]benzothiazole derivatives (**11** and **12**, respectively) in the presence of the PW, commercial CM-MgO, and HSA-MgO catalysts (Scheme 7). The catalysts were found to greatly affect the rates and the yields of the reactions. The results obtained are summarized in Table 2.

Though we did not yet establish the mechanism of the formation of 4*H*-pyrimido[2,1-*b*]benzoazoles, a probable pathway of the reaction is shown in Scheme 8. Apparently, the reaction takes place in two steps: the Knoevenagel condensation of aldehyde and β-ketoester gives 2-benzylidene-3-oxobutanoate (**13**); then, the Michael addition of 2-aminobenzimidazole **1a** or 2-aminobenzothiazole **1b** to compound **13** leads to compound **14**, cyclization of which results in 4*H*-pyrimido[2,1-*b*]benzoazoles **11**.

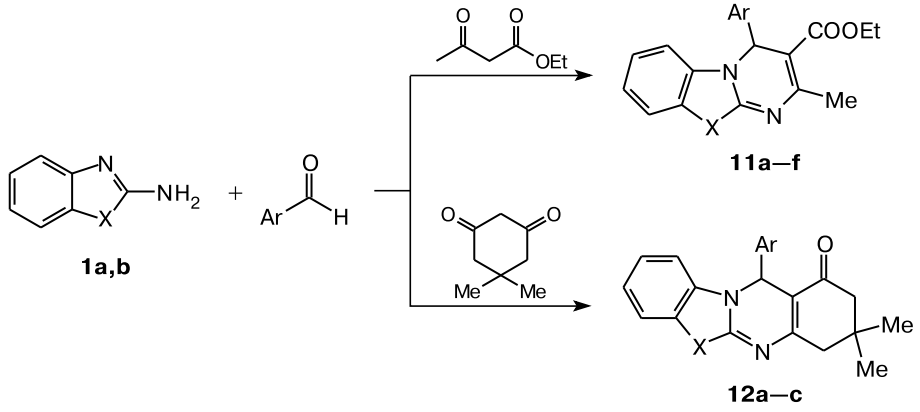
The structures of compounds **2a**—**f** were established based on elemental analysis, IR spectroscopy, ^{1}H and ^{13}C NMR spectroscopy, as well as mass spectrometry. The IR spectra of these compounds exhibit an absorption band of the CN group in the region 2235—2238 cm^{-1} and two sharp bands at 3450—3400 and 3370—3300 cm^{-1},

Scheme 6



i. 12 h.

Scheme 7



Scheme 8

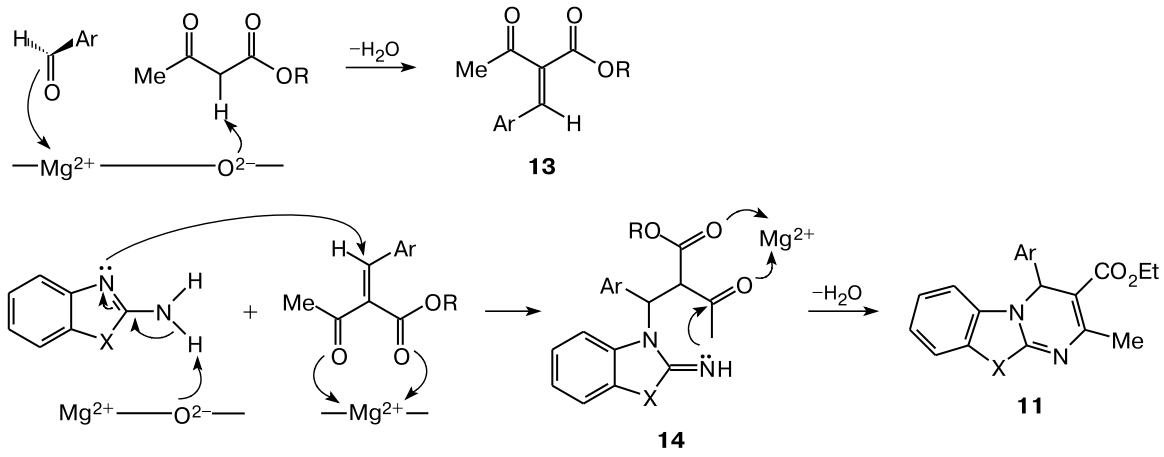


Table 2. Synthesis of compounds **11a—f** and **12a—c** in the presence of various catalysts

Compound	Ar	X	M.p./°C [Ref.]	CM/HSA(MgO)		PW	
				t/min	Yield (%)	*t*/min	Yield (%)
11a	Ph	S	172—175 [21]	40/5	45/95	7	95
11b	4-$MeOC_6H_4$	S	140—143 [21]	55/10	35/93	12	90
11c	4-$NO_2C_6H_4$	S	150—152 [21]	63/12	55/89	12	79
11d	Ph	N	291—293 [22]	45/10	50/90	15	85
11e	4-$MeOC_6H_4$	N	270—272 [22]	70/14	55/85	20	87
11f	4-$NO_2C_6H_4$	N	225 (decomp.) [21]	43/10	45/87	10	84
12a	Ph	S	226—227 [10]	35/5	55/90	7	85
12b	2-$MeOC_6H_4$	S	236—240 [10]	50/10	40/87	20	67
12c	3-$MeOC_6H_4$	S	241—243 [10]	75/22	40/86	40	80

corresponding to the asymmetric and symmetric vibration of the NH_2 group. Compounds **11a—f** and **12a—c** are described in the literature.[21—24] The IR spectra and melting points of all the known compounds agree with those described in the literature.

In conclusion, we described three-component reactions of 2-aminobenzimidazole or 2-aminobenzothiazole as a 1,3-binucleophiles, aldehydes, and malononitrile (or β-ketoesters) in the presence of catalysts, MgO and PW, which rapidly and in high yields furnish 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*][1,3]benzazole-3-carbonitriles and 4*H*-pyrimido[2,1-*b*][1,3]benzazole derivatives, respectively.

Experimental

Melting points were determined on a Gallencamp apparatus and were not corrected. IR spectra were recorded on a Mattson 1000 FT-IR spectrometer, ^1H and ^{13}C NMR spectra were recorded on a Bruker DRX-500 Avance spectrometer (500 and 125.77 MHz, respectively) in DMSO-d_6, using Me_4Si as an internal standard. Mass spectra were obtained on Shimadzu QP 1100 EX mass spectrometer (70 eV). Elemental analysis was performed on a Heraeus CHN-O-Rapid analyzer.

Preparation of MgO with highly developed surface. The catalysts used in this work were obtained by calcination of $Mg(OH)_2$ hydrate at 450 °C for 2 h.

***N*-(Benzimidazol-2-yl- or benzothiazol-2-yl)-*N*-alkylideneamines 8a—d.** The reactions were carried out in a standard round-bottom flask equipped with a reflux condenser with heating. A mixture of aldehyde **3** (2 mmol) and 2-aminobenzazole **1a** or **1b** (2 mmol) in acetonitrile (40 mL) was refluxed with stirring for 1 h. Then, the reaction mixture was cooled, a precipitate of product **8** was filtered off and recrystallized from ethanol.[34]

Synthesis of 4-amino-2-aryl-2*H*-pyrimido[1,2-*b*][1,3]benzimidazole-3-carbonitriles or -benzothiazole-3-carbonitriles 2a—f (general procedure). Method *A*. A mixture of 2-aminobenzimidazole or 2-aminobenzothiazole **1** (2 mmol), aldehyde (2 mmol), and malononitrile (2 mmol) in MeCN (25 mL) was refluxed with stirring in the presence of commercial MgO or MgO with highly developed surface (0.25 g). The reaction of was carried out until completion (TLC monitoring). The solvent was allowed to evaporate at ~20 °C, then ethanol (30 mL) was added, and the reaction mixture was stirred. The undissolved catalyst was filtered off, the filtrate was concentrat-

ed. The product obtained was purified by crystallization from ethanol.

Method *B*. The synthesis was carried out similarly to method *A* in the presence of PW (0.25 g).

4-Amino-2-phenyl-2,10-dihydropyrimido[1,2-*a*][1,3]benzimidazole-3-carbonitrile (2a). Method *A*. The yield was 0.52 g (94%), m.p. 201—203 °C. IR (KBr), ν_{max}/cm^{-1}: 3350, 3110 (br, NH_2, NH); 2175 (CN), 1650, 1620 (C=N). MS, *m/z* (I_{rel} (%)): 287 $[M]^+$, (30), 286 (30); 210 (100); 133 (90); 105 (17); 90 (20); 77 (28); 51 (18); 43 (27). Found (%): C, 70.75; H, 4.38; N, 24.06. $C_{17}H_{13}N_5$. Calculated (%): C, 71.07; H, 4.56; N, 24.37. ^{1}H NMR, δ: 8.57 (s, 1 H, NH); 8.07—6.99 (m, 9 H, Ar); 6.78 (s, 2 H, NH_2); 5.20 (s, 1 H, CH). ^{13}C NMR, δ: 151.70, 149.06 (C=N); 143.60, 142.89, 129.26, 128.63, 127.77, 125.86, 123.26, 119.79, 119.07 (CN), 116.02, 112.34, 61.98 (C(3)), 53.23 (C(2)).

4-Amino-2-(4-chlorophenyl)-2,10-dihydropyrimido[1,2-*a*]-[1,3]benzimidazole-3-carbonitrile (2b). Method *A*. The yield was 0.6 g (95%), m.p. 209—210 °C. IR (KBr), ν_{max}/cm^{-1}: 3438, 3336, 3100 (br, NH_2, NH); 2187 (CN); 1676, 1651 (C=N). MS, *m/z* (I_{rel} (%)): 321 $[M]^+$, (8), 306 (12); 230 (32); 216 (30); 188 (35); 171 (15); 119 (23); 105 (100); 91 (85); 77 (45); 57 (27); 51 (18); 43 (84); 41 (19). Found (%): C, 63.20; H, 3.39; N, 12.43. $C_{17}H_{12}ClN_5$. Calculated (%): C, 63.46; H, 3.76; N, 21.77. ^{1}H NMR, δ: (s, 1 H, NH); 7.64—6.98 (m, 8 H, Ar); 6.83 (s, 2 H, NH_2); 5.25 (s, 1 H, CH). ^{13}C NMR, δ: 151.54, 149.18 (C=N); 143.55, 141.77, 132.39, 129.23, 128.63, 127.89, 123.32, 119.87, 118.93 (CN); 118.08, 112.39, 61.51 (C(3)); 52.59 (C(2)).

4-Amino-2-(2,4-dichlorophenyl)-2,10-dihydropyrimido[1,2-*a*]-[1,3]benzimidazole-3-carbonitrile (2c). Method *A*. The yield was 0.64 g (90%), light yellow crystals, m.p. 212—214 °C. IR (KBr), ν_{max}/cm^{-1}: 3412, 3310, 3210 (br, NH_2, NH); 2187 (CN); 1676, 1627 (C=N). MS, *m/z* (I_{rel} (%)): 356 $[M]^+$, (10), 396 (33); 119 (30); 111 (35); 91 (20); 77 (15); 58 (30); 43 (100). Found (%): C, 56.96; H, 3.00; N, 19.43. $C_{17}H_{11}Cl_2N_5$. Calculated (%): C, 57.32; H, 3.11; N, 19.66. ^{1}H NMR, δ: 8.48 (s, 1 H, NH); 7.67—6.99 (m, 7 H, Ar); 6.88 (s, 2 H, NH_2); 5.64 (s, 1 H, CH). ^{13}C NMR, δ: 151.50, 149.55 (C=N); 143.49, 138.33, 133.31, 132.42, 129.96, 129.23, 129.08, 128.05, 123.37, 119.98, 118.29 (CN); 119.09, 112.41, 60.36 (C(3)); 50.54 (C(2)).

4-Amino-2-phenyl-2*H*-pyrimido[2,1-*b*][1,3]benzothiazole-3-carbonitrile (2d). Method *A*. The yield was 0.55 g (91%), light brown crystals, m.p. 197—199 °C. IR (KBr), ν_{max}/cm^{-1}: 3344, 3204 (br, NH_2); 2174 (CN); 1612 (C=N); 1542 (C=C). MS, *m/z* (I_{rel} (%)): 304 $[M]^+$, (10), 286 (100); 206 (11); 149 (8); 111 (7); 91 (5); 58 (9); 43 (32). Found (%): C, 66.89; H, 3.75; N, 18.11. $C_{17}H_{12}N_4S$. Calculated (%): C, 67.09; H, 3.97; N, 18.41. ^{1}H NMR, δ: 7.75—6.96 (m, 11 H, Ar, NH_2); 4.75 (s, 1 H, CH). ^{13}C NMR, δ: 160.63, 160.18, 136.03, 135.86 134.89, 133.61, 128.92, 128.63, 113.74, 113.59, 113.48, 112.56 (CN), 92.03, 80.28 (C(3)); 60.47 (C(2)).

4-Amino-2-(4-chlorophenyl)-2*H*-pyrimido[2,1-*b*][1,3]benzothiazole-3-carbonitrile (2e). Method *A*. The yield was 0.62 g (93%), yellow crystals, m.p. 215—217 °C. IR (KBr), ν_{max}/cm^{-1}: 3361, 3208 (br, NH_2); 2184 (CN); 1636, 1620 (C=N). MS, *m/z* (I_{rel} (%)): 338 $[M]^+$, (54), 336 (100); 310 (49); 271 (59); 150 (54); 134 (78); 108 (33); 90 (38); 58 (35); 43 (42). Found (%): C, 59.97; H, 3.05; N, 16.24. $C_{17}H_{11}ClN_4S$. Calculated (%): C, 60.27; H, 3.27; N, 16.54. ^{1}H NMR, δ: 8.33—6.89 (m, 10 H, Ar, NH_2); 4.03 (s, 1 H, CH). ^{13}C NMR, δ: 159.69, 158.53, 158.40, 153.00, 135.98, 134.49, 133.17, 130.88, 129.78, 128.42, 127.99, 123.83, 117.74, 91.00, 80.14.

4-Amino-2-(4-methylphenyl)-2*H*-pyrimido[2,1-*b*][1,3]-benzothiazole-3-carbonitrile (2f). Method *A*. The yield was 0.57 g (90%), light green crystals, m.p. 199—200 °C. IR (KBr), ν_{max}/cm^{-1}: 3320, 3210 (br, NH_2); 2178 (CN); 1632, 1618 (C=N). MS, *m/z* (I_{rel} (%)): 318 $[M]^+$, (10), 316 (100); 290 (36); 251 (45); 199 (12); 140 (14); 134 (20); 109 (11); 91 (22); 69 (15); 65 (18); 58 (11); 43 (52); 41 (12). Found (%): C, 67.63; H, 4.33; N, 17.38. $C_{18}H_{14}N_4S$. Calculated (%): C, 67.90; H, 4.43; N, 17.60. ^{1}H NMR, δ: 8.10—6.82 (m, 10 H, Ar, NH_2); 4.58 (s, 1 H, CH); 2.38 (s, 3 H, Me). ^{13}C NMR, δ: 160.59, 156.55, 154.31, 141.63, 137.06, 132.24, 130.81, 129.94, 129.05, 128.25, 124.05, 122.26, 116.54, 89.46, 55.08, 20.99 (Me).

4-Amino-2-(4-methylphenyl)-4*H*-[1,3]thiazino[3,2-*a*]benzimidazole-3-carbonitrile (10). A mixture of 1*H*-benzimidazole-2-thiol **9** (2 mmol), 4-methylbenzaldehyde (2 mmol), and malononitrile (2 mmol) in MeCN (25 mL) was refluxed with stirring in the presence of MgO with highly developed surface (0.25 g). The reaction of was carried out until completion (15 min, TLC monitoring), then the solvent was allowed to evaporate at ~20 °C, ethanol (30 mL) was added, and the reaction mixture was stirred. The undissolved catalyst was filtered off, the filtrate was concentrated. The product obtained was purified by crystallization from ethanol. The yield was 0.57 g (90%), yellow crystals, m.p. 220—222 °C. IR (KBr), ν_{max}/cm^{-1}: 3282, 2941 (br, NH_2); 2176 (CN); 1581, 1520 (C=N). MS, *m/z* (I_{rel} (%)): 318 $[M]^+$, (23), 306 (8); 185 (12); 157 (12); 136 (8); 119 (100); 111 (23); 91 (60); 77 (12); 65 (19); 43 (38); 41 (22); 150 (54); 134 (78); 108 (33); 90 (38); 58 (35); 43 (42). Found (%): C, 67.71; H, 4.30; N, 17.34. $C_{18}H_{14}N_4S$. Calculated (%): C, 67.90; H, 4.43; N, 17.60. ^{1}H NMR, δ: 7.66—6.85 (m, 10 H, Ar, NH_2); 5.15 (s, 1 H, CH); 2.33 (s, 3 H, Me). ^{13}C NMR, δ: 160.61, 160.15, 139.38, 138.89, 138.29, 132.88, 131.97, 130.73, 129.17, 128.66, 127.64, 121.21, 113.71, 112.64, 49.88, 20.68 (CH_3).

Synthesis of 4*H*-pyrimido[2,1-*b*]benzimidazole or 4*H*-pyrimido[2,1-*b*]benzothiazole derivatives 11a—f and 12a—c (general procedure). Compounds **11a—f** and **12a—c** were obtained according to the procedure described for the synthesis of **2a—f** with the replacement of malononitrile with ethyl acetoacetate or dimedone.

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