Regioselectivity in the Reaction of 2-Aminobenzothiazoles and 2-Aminobenzimidazoles with Enaminonitriles and Enaminones: Synthesis of Functionally Substituted Pyrimido[2,1-*b*][1,3]benzothiazole and Pyrimido[1,2-*a*]benzimidazole Derivatives

Abdulaziz Alnajjar,[a] Mervat Mohammed Abdelkhalik,[a]* Hossam Mohammed Riad,[b] Samia Mohammed Sayed,[b] and Kamal Usef Sadek[b]

[a]Applied Science Department, College of Technological Studies, Public Authority for Applied Education and Training, P.O. Box 42325, Safat, 70654, Kuwait
[b]Chemistry Department, Faculty of Science, Minia University, Minia 61519, Egypt
*E-mail: mervatak@yahoo.com

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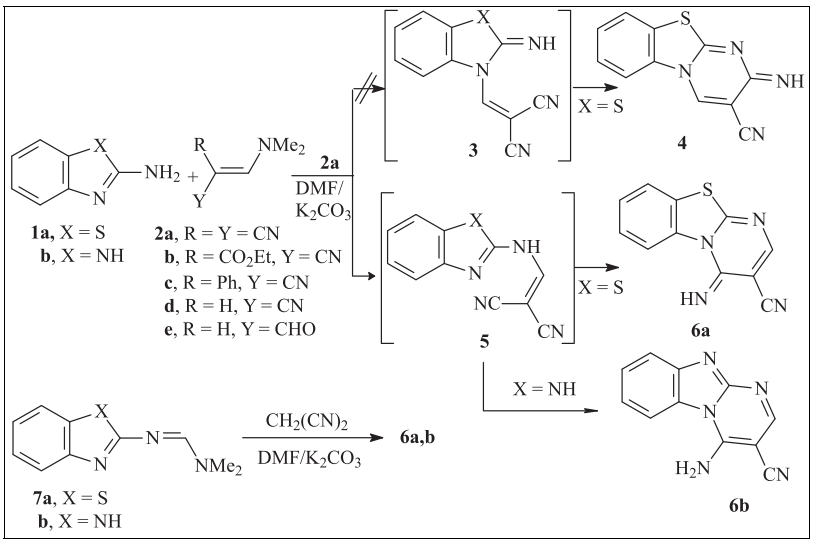

A variety of new polyfunctionally substituted benzo[*d*]pyrimido[2,1-*b*][1,3]thiazole and benzo[4,5]imidazo[1,2-*a*]pyrimidine derivatives have been synthesized. The general synthetic procedure used for this purpose involves the condensation of 2-aminobenzothiazole and 2-aminobenzimidazole with a variety of enaminonitriles, enaminones, and acrylaldehyde. The regioselectivity for initial attack of either endocyclic ring nitrogen or exocyclic amino group was studied and rationalized for. It has been concluded that ring nitrogen is the most reactive cite in acidic medium, and cyclic intermediate can also be isolated, attesting to this conclusion upon cyclization. However, in basic or neutral medium, the exocyclic amino group was found to be the most reactive center. All structures of the newly synthesized compounds were elucidated by elemental analysis, spectral data, and alternative synthetic route whenever possible.

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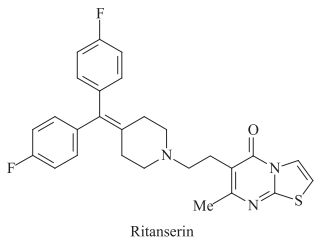
INTRODUCTION

Among the nitrogenous heterocycles, benzothiazoles and benzimidazoles have received great interest over the years because of their diversity biological activities [1,2]. Among those, pyrimidothiazole and pyrimidoimidazole derivatives possess a broad spectrum of biological activities. Pyrimidothiazole derivatives are reported to possess antitumor [3–5], anti-inflammatory [6], and antimicrobial [7,8] agents. In addition, the known Ritanserin acts as an antidepressant and 5-HT2A receptor antagonist. Pyrimidoimidazoles, being a purine analog, reveals a broad spectrum of pharmacological profile as local anesthetic and calcium channel-blocking agents [9]. In addition, they act as a fluorophore, which can be utilized as great photochemical sensors [10].



Ritanserin

There are few reports available concerning the synthesis of pyrimidothiazoles or pyrimidoimidazole-imino and/or pyrimidoimidazole-one derivatives [11–13]. 4-Imino-3,4-

dihydro-2*H*-pyrimido[2,1-*b*][1,3]benzothiazole-2-one has been synthesized by the reaction of 2-aminobenzothiazole with ethyl cyanoacetate in either ethoxide/ethanol or phosphoric acid [10] as well as under neat conditions [14], or with bis(methylthio)methylene malononitrile [15] in dimethylformamide (DMF)/K_2CO_3.

A few methods for accessing pyrimido[1,2-*a*] benzimidazoles are reported in literature. The main procedure involves either the reaction of ylidene malononitriles with 2-aminobenzimidazole [14] or multicomponent reaction of 2-aminobenzimidazole, malononitrile, and aromatic aldehydes [4].

An unresolved issue, in the nucleophilic addition of 2-aminothiazole and 2-aminobenzimidazole to electrophiles, is the regioselectivity of addition to either of the two active centers, namely, the ring nitrogen or exocyclic amino group. Modranka *et al*. [15] reported that the difference in regioselectivity is caused by the different substrate structures of electrophile rather than the reaction conditions. However, Petrova and coworkers [16] revealed that initial attack by exocyclic amino function afforded kinetically controlled zwitterionic compound that undergoes rearrangement to the corresponding ring nitrogen adduct in high-boiling solvents followed by intramolecular cyclization.

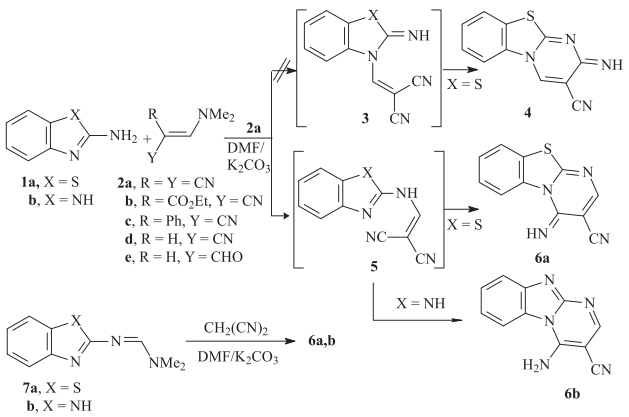
In continuation of our studies, we aimed to develop efficient simple routes for the synthesis of diversities-substituted heterocycles [17–19]. We report herein the results of our investigations concerning the regioselectivity in reaction of 2-aminobenzothiazole and 2-aminobenzimidazole with enaminonitriles, acrylaldehyde, and enaminones. A variety of functionally substituted pyrimido[2,1-*b*][1,3]benzothiazole and pyrimido[1,2-*a*] benzoimidazole derivatives are obtained in good to excellent yields.

RESULTS AND DISCUSSION

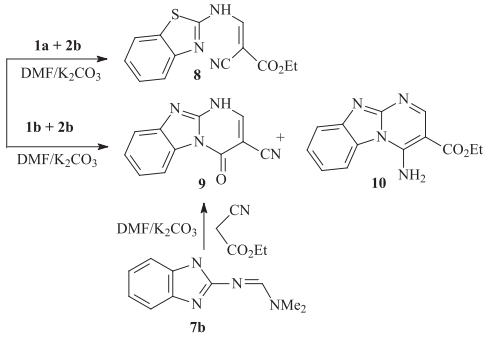
We began this study by treating 2-aminobenzothiazole **1a** with [(dimethylamino)methylene malononitrile] **2a** in DMF in the presence of catalytic amount of anhydrous potassium carbonate and heating under reflux for 3 h. The mass spectrum of the reaction product showed a molecular ion peak at *m*/*z* = 226.0 (100%). IR spectra revealed absorption bands for cyano and NH function. Two isomeric structures were postulated for the reaction product. These may be formulated as 2-imino-pyrimido[2,1-*b*][1,3] benzothiazole-3-carbonitrile **4** resulting from the initial attack of endocyclic ring nitrogen followed by intramolecular cyclization to the cyano group, or reversed sequence via initial attack of exocyclic amino function and subsequent cyclization with the participation of the endocyclic ring nitrogen affording the 4-imino derivative **6a**. Structure **6a** was established on the basis of the analytical and spectral data; in addition, it has been directly synthesized via alternative route (cf. Scheme 1). The most characteristic ^{1}H NMR peaks of **6a** in favor of structure **4** is a singlet at δ = 9.41 ppm for –C═NH proton and singlet at δ = 8.21 ppm for H-2. For structure **4**, such signals would appear at a higher field shift. Moreover, ^{13}C NMR chemical shift of the enamine carbon at C-4 appears at higher field shift δ = 166.86 ppm. If the reaction product was **4**, it would appear at a downfield shift δ ≈ 195 ppm. Structure **6a** was further confirmed via reaction of *N*′-(benzo[*d*]thiazol-2-yl)-*N*,*N*-dimethylformamidine **7a** with malononitrile under the same reaction conditions. Similarly, **1b** reacted with **2a** to afford the corresponding 4-aminopyrimido[1,2-*a*]benzimidazole-3-carbonitrile **6b**. The structure assigned for **6b** was established on the basis of analytical and spectral data or direct synthesis via alternative synthetic route through reaction of *N*′-(benzo[*d*]imidazol-2-yl)-*N*,*N*-dimethylformamidine **7b** with malononitrile (cf. Scheme 1).

We next expanded the scope and limitation of the reaction of **1a**,**b** with a variety of enaminonitriles and acrylaldehyde. The reaction of **1a** with ethyl 2-cyano-3-(dimethylamino)-acrylate **2b** afforded the corresponding thermodynamically controlled ethyl 3-(benzo[*d*]thiazol-2-ylamino)-2-cyanoacrylate **8**. The structure of **8** was deduced from its ^{1}H NMR, ^{13}C NMR, mass spectrum, and elemental analysis. Attempts to cyclize **8** under acidic or basic conditions were unsuccessful. In contrast, compound **1b** was reacted with **2b** under the same reaction conditions to afford a mixture of two products, **9** and **10**, in 2:1 ratio (cf. Scheme 2). Mass spectra of the product mixture showed molecular peak at *m*/*z* = 210 (100%) for **9** and 256 (15%) for **10**. Compounds **9** and **10** could not be separated but could be established on the basis of ^{1}H NMR integration of the product mixture, which displayed aromatic protons being

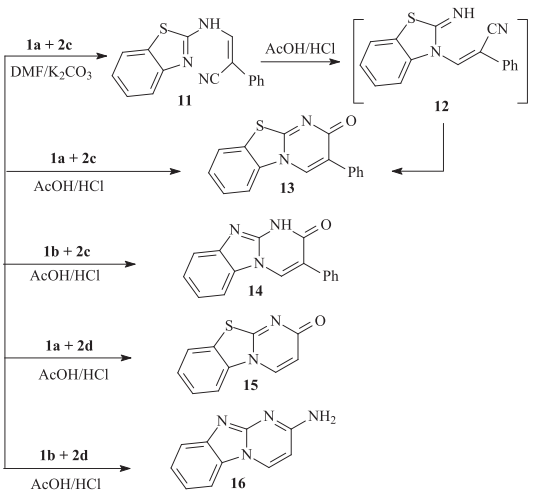
Scheme 1. Reaction of 2-aminobenzothiazole and 2-aminobenzimidazole **1a**,**b** with enaminonitrile **1a**.



Scheme 2. Reaction of 2-aminobenzothiazole and 2-aminobenzimidazole **1a**,**b** with ethyl 2-cyano-3-(dimethylamino)-acrylate **2a**.



Scheme 3. Reaction of 2-aminobenzothiazole and 2-aminobenzimidazole with enaminonitriles **2c**,**d**.



doubled with intensity 2:1, in addition to NH_2 and NH proton signals at δ = 8.60 and 8.43 ppm, respectively, as well as pyrimidine 2-H at δ = 8.84 ppm and 8.58 ppm. The reaction was assumed to proceed via initial attack with exocyclic amino group followed by cyclization either via loss of ethanol to afford **9** or addition to cyano function yielding **10**. The higher ratio of **9** could be rationalized for by the fact that cyclization via loss of ethanol molecule is more thermodynamically favorable. An alternative route to the target compound **9** as sole product was found in reacting **7b** with ethyl cyanoacetate in DMF in the presence of catalytic amount of potassium carbonate (cf. Scheme 2).

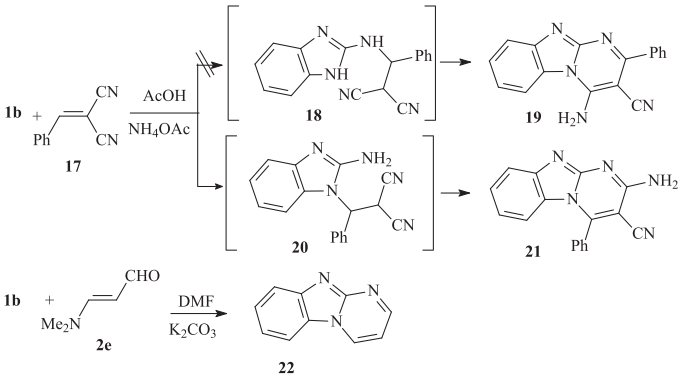
The reaction of **1a** with **2c** in DMF/K_2CO_3 afforded acyclic product **11** that formed via initial attack by exocyclic amino group. The ^{1}H NMR revealed a doublet signal at δ = 7.19 ppm integrated for 1 proton assigned for to ylidene C-2 proton in addition to NH signal at δ = 11.5 ppm as a doublet. However, conducting the reaction in AcOH/HCl mixture (20:2) under refluxing condition furnished the benzo[*d*]pyrimido[2,1-*b*][1,3] thiazol-2-one derivative **13** via initial attack at ring nitrogen followed by intramolecular cyclization. The difference in behavior can be explained by the fact that in acidic medium, protonation of exocyclic amino function renders ring nitrogen the more active center. Similarly, **1b** reacted with **2c** to afford benzimidazo[1,2-*a*] pyrimidine-2-one derivative **14**. Compounds **1a**,**b** reacted with **2d** to afford **15** and **16** (cf. Scheme 3).

It has been reported that the multicomponent reaction of malononitrile, aromatic aldehydes, and 2-aminobenzimidazole was refluxed in water for 12 h [4] or under almost basic condition [17–19] afforded 4-amino-1,2-dihydropyrimido[1,2-*a*]benzimidazole derivatives. However, we tried the reaction of **1b** and benzylidene malononitrile **17** in different reaction conditions other than those reported earlier. When compound **1b** was treated with **17** in AcOH/$AcONH_4$, we obtained a compound of molecular ion peak *m*/*z* = 285; however, physical and spectral characteristics were different. 2-Amino-4-phenylpyrimido[1,2-*a*]benzimidazole-3-carbonitrile **21** was proposed for the reaction product. ^{1}H NMR revealed mainly amino function at δ = 8.53 ppm. If the reaction product was 4-aminopyrimido[1,2-*a*]benzimidazole derivative **19**, it would have appeared at a higher field shift δ ≈ 6.96 ppm [4].

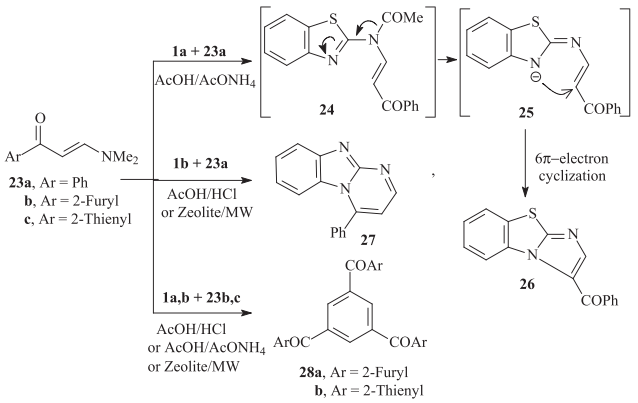
This synthetic approach was extended to the synthesis of unsubstituted pyrimido benzimidazole through the reaction of **1b** with 3-(dimethylamino)acrylaldehyde **2e** in DMF/K_2CO_3 and reflux for 3 h; product 22 was obtained in good yield.

It has been previously reported that the reaction of 2-aminobenzimidazole **1b** with 3-aryl-2-(dimethylamino) methylene-3-oxopropanenitriles in ethanol in the presence of catalytic amount of piperidine afforded mainly the 2-arylpyrimido[1.2-*a*]benzimidazole derivatives [20]. In order to shed further light on the regioselectivity of such reaction, we want to study the reaction of **1a**,**b** with enaminones **23a**–**c**. The reaction of **1a** with enaminone **23a** in AcOH/HCl and heating under reflux for 3 h resulted in the formation of benzothiazolo[3,2-*b*] imidazole derivative **26** via initial attack of exocyclic amino group followed by 6π-electron cyclization. However, the reaction of **1b** with **23a** under the same experimental conditions afforded the corresponding 4-phenylpyrimido[1,2-*a*]pyrimidine derivative **27** via initial attack of ring nitrogen and cyclization via water elimination. The structures proposed were established on analytical and spectral data. In contrast, the reaction of **1a**,**b** with **23b**,**c** afforded polyfunctionally substituted benzene derivatives **28b**,**c** formed via trimerization of **23b**,**c** in agreement with previous report by Behbahani *et al*. [21] (cf. Schemes 4 and 5).

Scheme 4. Reaction of 2-aminobenzothiazole **2a** with benzylidene malononitrile **17** and 3-(dimethylamino) acrylaldehyde **2e**.



Scheme 5. Reaction of **2a**,**b** with enaminones **23a**–**c**.



CONCLUSION

In summary, we can reveal that the reaction of 2-aminobenzothiazole and 2-aminobenzimidazole as weak nucleophiles with electrophilic reagents proceeds by initial attack on the most basic endocyclic nitrogen, which undergoes rearrangement to the corresponding less sterically hindered exocyclic amino group upon boiling in high-boiling solvents in basic or neutral medium.

Also, in acidic medium, protonation of exocyclic amino group renders ring nitrogen the most active center for initial attack followed by intramolecular cyclization. In establishing the regioselectivity in such reactions, all reaction pathways should not be overlooked, and convincing evidences should be utilized for confirmation of the structure of products.

EXPERIMENTAL

Melting points were determined on a Gallenkamp melting point apparatus (Gemini BV Laboratory, DG Apeldoom, Netherlands) and were uncorrected. Infrared spectra were obtained with a Shimadzu Model 470 FT spectrophotometer (Shimadzu Corporation, Kyoto, Japan). The ^{1}H NMR and ^{13}C NMR spectra were recorded using a Bruker AM 400 spectrophotometer (Brucker Corporation, Billeria, MA) with DMSO-d_6 as a solvent and tetramethylsilane as internal standard. Chemical shifts are expressed as δ (ppm). Mass spectra were measured on a GCMSQP 1000 EX mass spectrometer. Analytical data (C, H, N, S) were determined on the ANALAB at Kuwait University (Leco CHNS-932, LECO Corporation, St. Joseph, MI). Analytical thin-layer chromatography was performed with silica gel plates using silica gel 60 PF 254 (Merck).

General procedure for the reaction of 2-aminobenzothiazole and 2-aminobenzimidazole with enaminonitriles, benzylidene malononitrile, and enaminones. To a solution of 2-aminobenzothiazole **1a** or 2-aminobenzimidazole **1b** (0.01 mol) in either DMF (10 mL) or catalytic amount of anhydrous K_2CO_3 (10 mol%) or in acetic acid HCl (10:2) was added enaminonitrile **2a**–**d**, 3-(dimethylamino) acrylaldehyde **2e**, benzylidene malononitrile **17**, or enaminone **23a-c** (0.01 mol). The reaction mixture was heated under reflux for the indicated time (thin-layer chromatography control). After workup of the reaction product, the solid product formed was collected by filtration and crystallized from the proper solvent.

An alternative route to **6a**,**b** and **9** was found in reacting **7a**,**b** with malononitrile or ethyl cyanoacetate in DMF (10 mL) in the presence of catalytic amount of anhydrous K_2CO_3 (10 mol%). The reaction mixture was heated under reflux for 3 h. After cooling and evaporation to dryness *in vacuo*, the remaining product was triturated with ethanol, and the crude product obtained was collected by filtration and crystallizes from the proper solvent to afford analytically pure samples identical with **6a**,**b** and **9**.

4-Iminopyrimido[2,1-b]benzothiazol-3-carbonitrile 6a. Crystals from ethanol, m.p. 188–190°C. Yield 80%, EST-MS: *m/z* = 226.0 (M^+, 100%). IR max/cm^{-1}: 3246 (imine NH), 2221 (CN), 1622 (C═N). ^{1}H NMR (DMSO-d_6, δ ppm) = 9.41 (br s, 1H, NH), 8.21 (s, 1H, H-2), 8.15–8.077 (m, 2H, Ar–H), 7.64–7.55 (m, 2H, Ar–H). ^{13}C NMR (DMSO-d_6, δ ppm) = 94.01, 115.54, 120.77, 122.77, 124.08, 126.81, 127.10, 136.51, 153.32, 153.73, 166.86. *Anal*. Calc. for $C_{11}H_6N_4S$ (226.26): C, 58.39; H, 2.67; N, 24.76; S, 14.17. Found: C, 58.33; H, 2.63; N, 24.66; S, 14.15.

4-Aminopyrimido[1,2-a]benzimidazole-3-carbonitrile 6b. Crystals from dioxane, m.p. > 300°C. Yield 75%, EST-MS: *m/z* = 209.0 (M^+, 100%). IR max/cm^{-1}: 3313 (NH_2), 2220 (CN), 1648 (C═N). ^{1}H NMR (DMSO-d_6, δ ppm) = 8.75 (br s, 2H, NH_2), 8.57–8.52 (m, 2H, Ar–H), 7.77 (s, 1H, H-2), 7.54–7.52 (m, 1H, Ar–H), 7.41–7.35 (m, 1H, Ar–H). *Anal*. Calc. for $C_{11}H_7N_5$ (209.21): C, 63.15; H, 3.37; N, 33.48. Found: C, 63.22; H, 3.35; N, 33.52.

Ethyl 3-(benzo[*d*]thiazol-2-ylamino)-2-cyanoacrylate 8. Crystals from ethanol, m.p. 164–165°C. Yield 83%, EST-MS: *m/z* = 273.0 (M^+, 76%). IR max/cm^{-1}: 3202 (NH), 2223 (CN), 1716 (ester C═O) 1686 (C═N). ^{1}H NMR (DMSO-d_6, δ ppm) = 12.4 (br s, 1H, NH), 8.85 (s, 1H, ylidene C–H), 7.98 (d, 1H, *J* = 7.6 Hz Ar–H), 7.79 (d, 1H, *J* = 8 Hz Ar–H),7.48–7.44 (m, 1H, Ar–H), 7.35–7.31 (m, 1H, Ar–H), 4.26 (q, 2H, *J* = 7.2 Hz OCH_2), 1.27 (t, 3H, *J* = 7.2 Hz CH_3). *Anal*. Calc. for $C_{13}H_{11}N_3O_2S$ (273.05): C, 57.13; H, 4.06; N, 15.37; S, 11.73. Found: C, 57.21; H, 4.07; N, 15.42; S, 11.66.

4-Oxo-1,4-dihydrobenzo[4,5]imidazo[1,2-*a*]pyrimidine-3-carbonitrile 9. Crystals from benzene, m.p. > 300°C. Yield 83%, EST-MS: *m/z* = 209.0 (M^+, 76%). IR max/cm^{-1}: 3104 (NH), 2221 (CN), 1664 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 8.58 (s, 1H, H-2), 8.43 (br s, 1H, NH), 8.43 (d, *J* = 7 Hz, 1H, NH), 7.62–7.58 (m, 2H, Ar–H), 7.55–7.48 (m, 2H, Ar–H). *Anal*. Calc. for $C_{11}H_6N_4O$ (209.19): C, 63.16; H, 2.41; N, 26.78. Found: C, 62.90; H, 2.45; N, 26.55.

3-(Benzo[*d*]thiazol-2-ylamino)-2-phenylacrylonitrile 11. Crystals from ethanol, m.p. 168–177°C. Yield 79%, EST-MS: *m/z* = 277.0 (M^+, 90%). IR max/cm^{-1}: 3395 (NH), 2223 (CN). ^{1}H NMR (DMSO-d_6, δ ppm) = 11.5 (d, 1H, *J* = 11.6 Hz, NH), 8.35 (d, 1H, *J* = 11.6 Hz ylidene C–H), 7.85 (d, 1H, *J* = 7.6 Hz, Ar–H), 7.64 (d, 1H, *J* = 7.6 Hz, Ar–H), 7.55–7.48 (m, 2H, Ar–H), 7.42–7.34 (m, 3H, Ar–H), 7.27–7.19 (m, 2H, Ar–H). *Anal*. Calc. for $C_{16}H_{11}N_3S$ (277.34): C, 69.29; H, 4.00; N, 15.15; S, 11.56. Found: C, 69.33; H, 4.11; N, 14.84; S, 11.52.

3-Phenyl-2H-benzo[*d*]pyrimido[2,1-*b*][1,3]thiazol-2-one 13. Crystals from benzene, m.p. 259–267°C. Yield 75%, EST-MS: *m/z* = 270 (M^+, 90%). IR max/cm^{-1}: 1676 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 9.04 (t, 1H, *J* = 5.2 Hz, Ar–H), 8.27 (s, 1H, H-4), 8.11 (t, 1H, *J* = 5.2 Hz, Ar–H), 7.77 (d, 2H, *J* = 7.6 Hz, Ar–H), 7.62 (t, 2H, *J* = 7.6 Hz, Ar–H), 7.49 (t, 2H, Ar–H), 7.43–7.39 (m. 1H, Ar–H). ^{13}C NMR (DMSO-d_6, δ ppm) = 119.74, 120.81, 123.54, 124.98, 127.34, 127.70, 128.21, 128.68, 129.08, 133.84, 136.50, 150.25, 160.17, 161.39. *Anal*. Calc. for $C_{16}H_{10}N_2OS$ (278.33): C, 69.05; H, 3.62; N, 10.06; S, 11.52. Found: C, 69.21; H, 3.76; N, 10.26; S, 11.40.

3-Phenyl-1,2-dihydrobenzo[4,5]imidazo[1,2-*a*]pyrimidin-2-one 14. Crystals from dioxane, m.p. 278–280°C. Yield 76%, EST-MS: *m/z* = 261.10 (M^+, 24.3%). IR max/cm^{-1}: 3170 (NH), 1643 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 10.53 (br s, 1H, NH), 8.53 (d, 1H, *J* = 8.4 Hz, Ar–H), 8.22 (s, 1H, H-4), 7.76–7.73 (m, 2H, Ar–H), 7.53–7.44 (m, 6H, Ar–H). *Anal*. Calc. for $C_{16}H_{11}N_3O$ (261.20): C, 73.55; H, 4.24; N, 16.08. Found: C, 73.60; H, 4.20; N, 16.18.

2H-Benzo[*d*]pyrimido[2,1-*b*][1,3]thiazol-2-one 15. Crystals from benzene, m.p. 128–131°C. Yield 76%, EST-MS: *m/z* = 202 (M^+, 15%). IR max/cm^{-1}: 1637 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 7.64 (d, 1H, *J* = 7.3 Hz, H-4), 7.42–6.84 (m, 4H, Ar–H), 6.97 (d, 1H *J* = 7.3 Hz, H-3). *Anal*. Calc. for $C_{10}H_6N_2OS$ (202.23): C, 59.39; H, 2.99; N, 13.85; S, 15.85. Found: C, 59.45; H, 3.02; N, 13.77; S, 15.74.

Benzo[4,5]imidazo[1,2-*a*]pyrimidin-2-ylamine 16. Crystals from ethanol, m.p. 293–295°C. Yield 82%, EST-MS: *m/z* = 185 (M^+, 100%). IR max/cm^{-1}: 3430 (NH_2), 1682 (C═N). ^{1}H NMR (DMSO-d_6, δ ppm) = 12.8 + 8.42 (two s, 2H, NH_2), 7.95 (d, 1H, *J* = 6.9 Hz, H-4), 7.55–7.28 (m, 4H, Ar–H), 5.95 (d, 1H, *J* = 6.9 Hz, H-3). *Anal*. Calc. for $C_{10}H_8N_4$ (184.20): C, 65.20; H, 4.38; N, 30.42. Found: C, 64.70; H, 4.42; N, 30.11.

2-Amino-4-phenylbenzo[4,5]imidazo[1,2-*a*]pyrimidine-3-carbonitrile 21. Crystals from ethanol, m.p. 220–222°C. Yield 74%, EST-MS: *m/z* = 285 (M^+, 17%). IR max/cm^{-1}: 3423 (NH_2), 2220 (CN). ^{1}H NMR (DMSO-d_6, δ ppm) = 8.53 (s, 2H, NH_2), 7.96–7.93 (m, 4H, Ar–H), 7.71–7.58 (m, 5H, Ar–H). *Anal*. Calc. for $C_{17}H_{11}N_5$ (285.31): C, 71.57; H, 3.89; N, 24.55. Found: C, 71.55; H, 3.78; N, 24.65.

Benzo[4,5]imidazo[1,2-*a*]pyrimidine 22. Crystals from ethanol, m.p. > 300°C. Yield 78%, EST-MS: *m/z* = 169 (M^+, 100%). ^{1}H NMR (DMSO-d_6, δ ppm) = 9.52–6.87 (m, 7H, Ar–H, H-2, H-3 and H-4). *Anal*. Calc. for

$C_{10}H_7N_3$ (169.19): C, 70.99; H, 4.17; N, 24.84. Found: C, 70.89; H, 4.15; N, 24.82.

Benzo[*d*]imidazo[2,1-*b*][1,3]thiazol-3-yl(phenyl)methanone 26. Crystals from ethanol, m.p. 120–122°C. Yield 84%, EST-MS: *m/z* = 278 (M^+, 15%). IR max/cm^{-1}: 1670 (CO). ^{1}H NMR (DMSO-d_6, δ ppm) = 9.07 (d, 1H, *J* = 8 Hz, Ar–H), 8.21–8.19 (m, 2H, Ar–H), 8.13 (d, 1H, *J* = 8 Hz, Ar–H), 7.98 (s, 1H, H-2), 7.64–7.56 (m, 5H, Ar–H). *Anal*. Calc. for $C_{16}H_{10}N_2OS$ (278.33): C, 69.05; H, 3.62; N, 10.06; S, 11.52. Found: C, 69.12; H, 3.68; N, 10.04; S, 11.32.

4-Phenylbenzo[4,5]imidazo[1,2-*a*]pyrimidine 27. Crystals from benzene, m.p. 288–290°C. Yield 76%, EST-MS: *m/z* = 245.0 (M^+, 100%). ^{1}H NMR (DMSO-d_6, δ ppm) = 9.58 (d, 1H, *J* = 7.2 Hz, H-2), 8.36–8.31 (m, 2H, Ar–H), 7.83–7.81 (m, 2H, Ar–H), 7.52 (d, 1H, *J* = 7.2 Hz, H-3), 7.52–7.39 (m, 5H, Ar–H). *Anal*. Calc. for $C_{16}H_{11}N_3$ (245.28): C, 78.35; H, 4.52; N, 17.13. Found: C, 78.30; H, 4.41; N, 17.28.

[3,5-di(2-Furylcarbonyl)phenyl](2-furyl)methanone 28a. Crystals from ethanol, m.p. 186–188°C, Lit m.p. 184–185 [21]. Yield 82%, EST-MS: *m/z* = 360.0 (M^+, 77%). IR max/cm^{-1}: 1650 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 8.59 (s, 3H, Ar–H), 8.21 (d, 3H, *J* = 2.0 Hz, furan H-5), 7.59 (d, 3H, *J* = 1.8 Hz, furan H-3), 6.48 (t, 3H, *J* = 2.0 Hz, furan H-4). ^{13}C NMR (DMSO-d_6, δ ppm) = 113.16, 122.14, 132.75, 137.38, 149.23, 151.04, 179.92. *Anal*. Calc. for $C_{21}H_{12}O_6$ (360.32): C, 70.00; H, 3.36. Found: C, 70.03; H, 3.37.

[3,5-di(2-Thienylcarbonyl)phenyl](2-thienyl)methanone 28b. Crystals from ethanol, m.p. 208–210°C Lit m.p. 203–204 [21]. Yield 85%, EST-MS: *m/z* = 408.0 (M^+, 37%). IR max/cm^{-1}: 1641 (C═O). ^{1}H NMR (DMSO-d_6, δ ppm) = 8.42 (s, 3H, Ar–H), 8.20 (d, 3H, *J* = 5.2 Hz, thiophene H-5), 7.91 (d, 3H, *J* = 4.0 Hz, thiophene H-3), 7.32 (t, 3H, *J* = 4.0 Hz, thiophene H-4), ^{13}C NMR (DMSO-d_6, δ ppm) = 129.13, 132.28, 136.46, 136.66, 138.13, 142.10, 185.98. *Anal*. Calc. for $C_{21}H_{12}O_3S_3$ (408.50): C, 61.74; H, 2.96, S, 23.54. Found: C, 61.76; H, 3.01; S, 23.44.

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