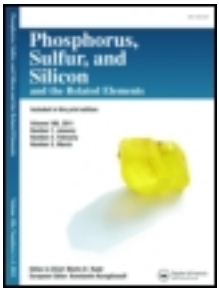

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Synthesis of Polyfunctionally Substituted Pyrazolonaphthyridine, Pentaazanaphthalene, and Heptaazaphenanthrene Derivatives

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Synthesis of Polyfunctionally Substituted Pyrazolonaphthyridine, Pentaazanaphthalene, and Heptaazaphenanthrene Derivatives

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*6-aminopyrazolo[3,4-*b*]pyridine-5-carbonitrile (**2**) was used as a precursor for the synthesis of a variety of pyrazolo[3,4-*b*][1,8]naphthyridines (**3**,**4**) and pentaazacyclopenta[*b*]naphthalenes (**5–10**, **13**, **14**) via the initial addition to either the cyano or amino group followed by cyclization. Also, a series of heptaazadicyclopenta[a, g]naphthalenes (**15–17**) and heptaazacyclopenta[b]phenanthrenes (**18**, **19**) were obtained via the interaction of 4-(dibenzothiophen-2-yl)-1,5-dihydro-5-imino-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-6-ylamine (**14**) with different reagents. The structures of the synthesized compounds were established by elemental and spectral analyses.*

Keywords Heptaazacyclopenta[*b*]phenanthrene; pentaazacyclopenta[*b*]naphthalene; pyrazolo[3,4-*b*]pyridine

INTRODUCTION

The pyrido[2,3-*d*]pyrimidine is a very common feature in many compounds of biological interest. Its employment gave good results in several fields of medicinal chemistry, such as antitumor, antifolate, antimycobacterial, and antihistamic chemistry.[1–5] They are also effective as centeral analgesics and as a new drug for the treatment of insomnia.[6–9] In addition, pyrazole has been the focus of high attention due to its versatile application in agriculture[10] and medicine[11] as antileukemia and antihypertensive activities.[12–14] In view of the aforesaid versatile benefits and as a continuation of our efforts,[15–17] we wish to report on a facile and convenient access to 6-amino-(4-dibenzothiophen-2-yl)-3-methyl-1-phenyl- 1*H*-pyrazolo[3,4-*b*]-pyridine-5-carbonitrile (**2**),

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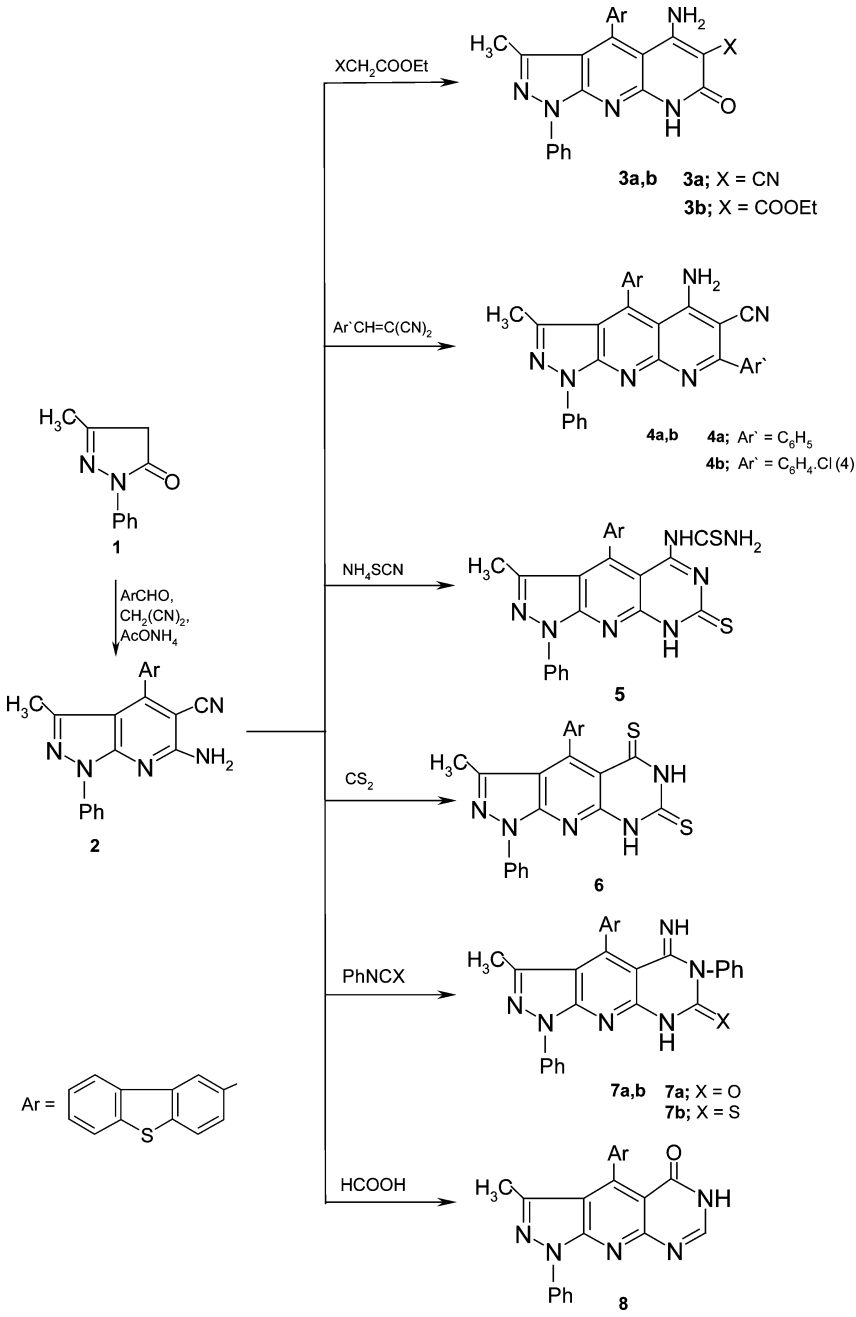
which was required in our laboratory as a key intermediate for the construction of novel unreported congeners bearing pyrazole and pyridopyrimidine moieties within a single molecular framework likely to constitute potent antimicrobial agents.

RESULTS AND DISCUSSION

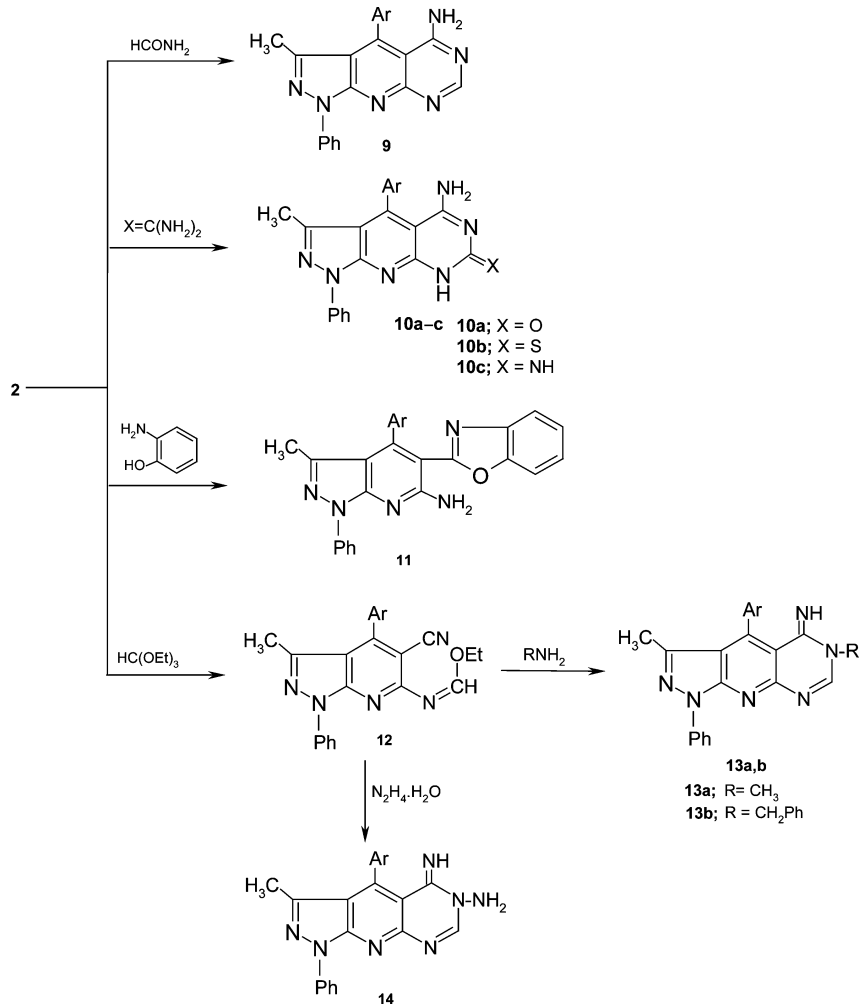
The one-pot reaction of 2,4-dihydro-5-methyl-2-phenylpyrazol-3-one (**1**), dibenzothiophene-2-carbaldehyde, and malononitrile in the presence of ammonium acetate afforded the required starting material, 6-amino-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1*H*-pyrazolo[3,4-*b*] pyridine-5-carbonitrile (**2**). The structure of **2** was assigned by elemental analyses and spectroscopic data; its IR spectrum showed characteristic bands at 3390, 3260 (ν_{NH2}), and 2215 cm^{-1}($\nu_{C\equiv N}$). The ^1H NMR spectrum ($CDCl_3$) showed signals (3H) at δ2.13 ppm assigned for methyl protons, at δ5.85 ppm (2H) assigned for NH_2, and multiplet signals (12H) at δ 7.18–8.23 ppm assigned for aromatic protons. Compound **2** was used as a precursor for the synthesis of new heterocyclic systems because it contains the enaminonitrile moiety, which is well known as a highly reactive and convenient reagent for the synthesis of nitrogen heterocycles.[18,19] Thus, the reaction of compound **2** with active methylene compounds[20] viz, ethyl cyanoacetate and diethyl malonate in the presence of ammonium acetate-acetic acid at 190–200°C furnished pyrazolo[3,4-*b*][1,8]-naphthyridine derivatives **3a,b** (Scheme 1).

The reaction of compound **2** with arylidenemalononitriles viz benzylidene-malononitrile and 4-chlorobenzylidenemalononitrile in refluxing dioxane[21] yielded 5-amino-7-aryl-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1*H*-pyrazolo[3,4-*b*][1,8]-naphthyridine-6-carbonitriles (**4a**,**b**). We have also investigated the possible utility of **2** to develop a facile and a convenient route to polyfunctionally substituted pyrazolopyridopyrimidine that was expected to have a broad spectrum of biological and physiological potential.[22] Thus, the reaction of compound **2** with ammonium thiocyanate in boiling acetic acid afforded [4-(dibenzothiophen-2-yl)-7,8-dihydro-3-methyl-1-phenyl-7-thioxo-1H-1,2,6,8,9-pentaazacyclopenta[*b*]naphthalen-2-yl]-thiourea (**5**). The refluxing of compound **2** with carbon disulfide in DMF gave the corresponding pentaazacyclopenta[*b*]naphthalene-5,7-dithione **6**, whose IR spectrum showed the absence of bands assignable to amino and cyano functional groups and displayed the presence of only two NH functional groups at 3390–3325 cm^{-1}. Similarly, the reaction of compound **2** with phenyl isocyanate, phenyl isothiocyanate, and formic acid afforded the expected tricyclic compounds **7a**,**b** and **8**, respectively (Scheme 1).



SCHEME 1

The enaminonitrile moiety in compound **2** proved to be highly reactive toward other nitrogen nucleophiles. Thus, the reaction of **2** with formamide, urea, thiourea, and guanidine hydrochloride afforded the corresponding pyrazolopyrido-pyrimidine derivatives **9** and **10a–c**, respectively (Scheme 2).



SCHEME 2

The incorporation of the benzoxazolyl moiety in a pyrazolopyridine system was achieved via the reaction of compound **2** with *o*-aminophenol in absolute ethanol containing a few drops of pyridine

to afford 5-(benzoxazol-2-yl)-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1*H*-pyrazolo[3,4-*b*]pyridin-6-ylamine (**11**). The conden-sation of compound **2** with triethyl orthoformate in refluxing acetic anhydride yielded the corresponding ethyl pyrazolo[3,4-*b*]pyridin-6-ylformimidate **12**, which underwent further cyclization upon treatment with methyl amine or benzyl amine and afforded 4-(dibenzothiophen-2-yl)-1,6-dihydro-3-methyl-6-methyl-/benzyl-1-phenyl-1,2,6,8,9-pentaazacyclopenta[*b*]naphthalen-5-ylideneamine (**13a**, **b**). The imidate derivative **12** gave 4-(dibenzothiophen-2-yl)- 1,5-dihydro-5-imino-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclopenta[*b*]naphthalen-6-ylamine (**14**) upon treatment with hydrazine hydrate at r.t.

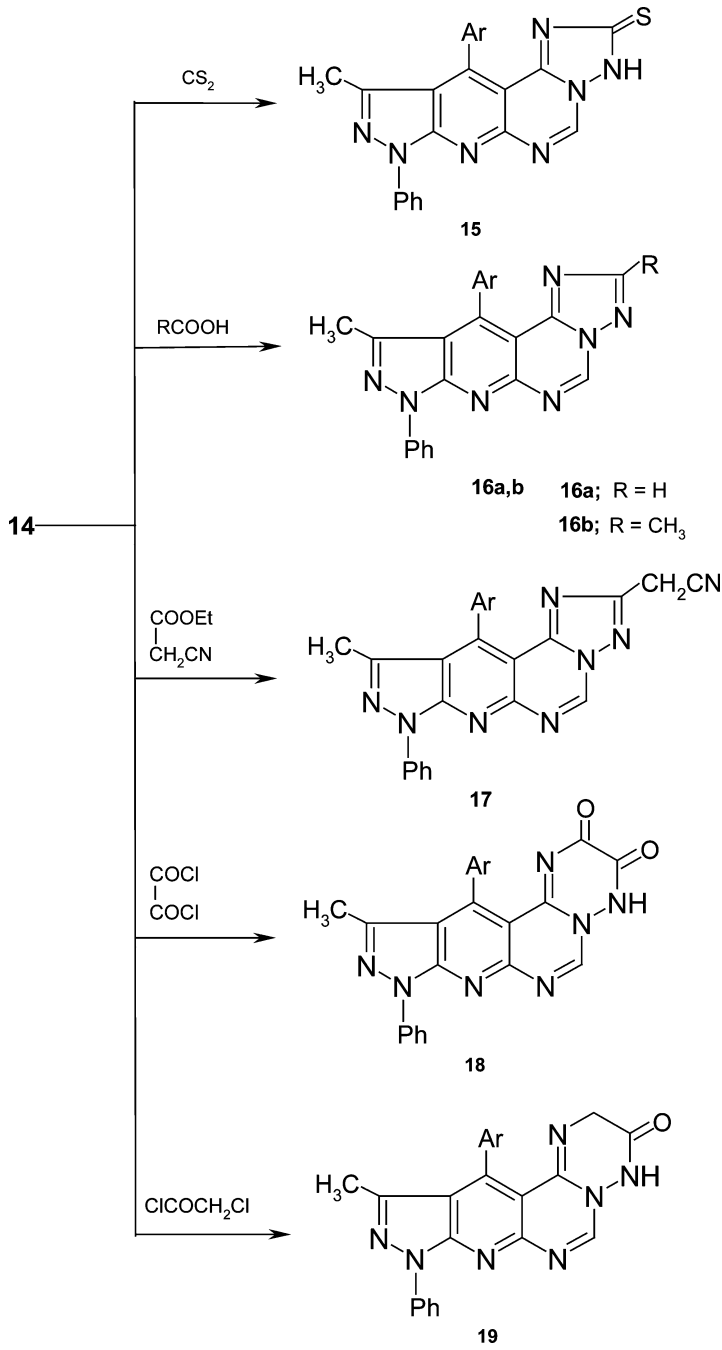
Pursuing our interest in the chemistry of pyrazolopyridopyrimidine, compound **14** was used as a useful intermediate for the preparation of triazole and triazine systems fused to the pyrimidine ring, which was expected to possess notable chemical and pharmacological activities.[23,24] Thus, the treatment of compound **14** with carbon disulfide afforded hepaatazadicyclopenta[*a*, *g*]naphthalene-2-thione **15** (Scheme 3). The reaction of compound **14** with carboxylic acids viz formic acid and acetic acid yielded 1,3,4,6,7,8,9-heptaazadicyclopenta[*a*, *g*]naphthalenes **16a**, **b**.

Furthermore, the treatment of compound **14** with ethyl cyanoacetate in refluxing absolute ethanol gave the expected acetonitrile derivative **17**, whose IR spectrum revealed a characteristic nitrile absorption band at 2220 cm^{-1}. Our interest in this study was also focused on the suitability of compound **14** for the construction of polyfunctionally substituted phenanthrenes. Thus, the reaction of compound **14** with oxalyl chloride in refluxing dry benzene afforded the phenanthrene-2,3-dione derivative **18**. In addition, the reaction of equimolar amounts of **14** and chloroacetyl chloride in dry dioxane yielded 12-(dibenzothiophen-2-yl)-2,9-dihydro- 11-methyl-9-phenyl-1,4,5,7,8,9,10-heptaaza-cyclopenta[*b*]phenanthren-3-one (**19**) (Scheme 3). Structures of the synthesized compounds were confirmed from their physical and spectral data (cf Experimental Section).

ANTIMICROBIAL ACTIVITY

The antimicrobial activity of some synthesized derivatives was examined toward various pathogenic bacteria and fungi in vitro using the hole plate and filter paper disc methods.[25] The tested compounds were dissolved in 10% acetone (v/v) at concentrations of 500, 250, and 125 μg/mL. The results are summarized in Table I.

In summary, the described method is experimentally simple and uses easily available starting materials and reagents and thus provides a



SCHEME 3

TABLE I The Antimicrobial Activity of the Tested Compounds

Compound No.	*Bacillus subtilis*		*Rhodococcus equi*		*Salmonella typhimurium*		*Escherichia coli*		*Aspergillus niger*		*Penicillium notatum*	
	A	MIC	A	MIC	A	MIC	A	MIC	A	MIC	A	MIC
2	++	500	++	500	++	250	++	250	+	125	+	500
3a	++	500	++	500	+++	500	++	500	++	250	+	250
4b	++	250	++	250	++	125	++	500	++	250	++	500
5	+++	250	+++	125	+++	250	+++	250	++	500	++	250
6	+++	125	+++	250	+++	250	+++	250	+	250	++	500
7b	+++	250	+++	250	+++	125	+++	125	++	125	+	250
9	+++	125	+++	125	+++	250	+++	125	+	250	++	500
11	+++	250	+++	250	++	500	+++	250	++	250	++	250
14	+++	125	+++	125	+++	125	++	500	+	125	+	125
15	+++	500	+++	125	+++	250	+++	125	++	250	++	250
17	+++	125	+++	250	+++	125	+++	125	+	500	+	250
19	+++	250	+++	125	+++	125	+++	250	++	500	++	500

A = Antimicrobial activity of tested compounds.

MIC = Minimum inhibitory concentration; + >5 mm, slightly active; ++ >7 mm, moderately active; +++ >9 mm, highly active.

convenient access to new tri- and tetracyclic heterocyclic systems of biological interest.

EXPERIMENTAL

Melting points are uncorrected. IR spectra in KBr were recorded on a Perkin-Elmer 298 spectrophotometer. ^{1}H and ^{13}C NMR spectra were obtained on an Varian Gemini 200 MHz and 50 MHz instrument using TMS as internal reference with chemical shifts expressed as δ ppm. Mass spectra were recorded on a Shimadzu GCMS-QP 1000 EX instrument (70 eV El mode). All reactions were monitored by TLC and carried out on 0.2-mm silica gel 60 F254 (Merck) plates.

6-Amino-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1H-pyrazolo[3,4-b]pyridine-5-carbonitrile (2)

A mixture of 2,4-dihydro-5-methyl-2-phenylpyrazol-3-one (**1**) (25 mmol), dibenzothiophene-2-carbaldehyde (25 mmol), malononitrile (25 mmol), and ammonium acetate (60 mmol) was heated in an oil bath at 180–190°C for 12 h. After cooling, the solid formed was washed with cold water, dried, and recrystallized from *n*-butanol to give **2**. Yield, 73%, m.p. 213–215°C; IR: ν = 3390, 3260 (NH_2), 2215 (C≡N), 1620–1610 cm^{-1} (C=N); ^{1}H NMR ($CDCl_3$): δ = 2.13 (s, 3H, CH_3), 5.85

(br s, 2H, NH_2), 7.18–8.23 (m, 12H, ArH); ^{13}C NMR: $\delta = 14.1$ (CH_3), 111.4 (C-3a), 119.3 (C-5), 121.4 (CN), 129.2 (C-7a), 141.5 (C-3), 145.2 (C-6), 148.3 (C-4), 113.2, 114.4, 120.3, 121.4, 123.4, 125.2 (C— of phenyl group), 121.3, 124.5, 126.7, 128.2, 129.6, 130.5, 131.5, 133.6, 134.6, 136.7, 137.2, 138.1 (C— of dibenzothiophene group); Anal. calcd. for $C_{26}H_{17}N_5S$ (431.51): C, 72.37; H, 3.97; N, 16.23%. Found: C, 72.56; H, 4.13; N, 16.01%.

5-Amino-4-(dibenzothiophen-2-yl)-7,8-dihydro-3-methyl-7-oxo-1-phenyl-1H-pyrazolo-[3,4-b][1,8]naphthyridine-6-carbonitrile (3a) and Ethyl 5-Amino-4-(dibenzothiophen-2-yl)-7,8-dihydro-3-methyl-7-oxo-1-phenyl-1H-pyrazolo-[3,4-b][1,8] naphthyridine-6-carboxylate (3b)

A mixture of **2** (5 mmol), ethyl cyanoacetate or diethyl malonate (5 mmol), ammonium acetate (15 mmol), and acetic acid (5 mL) was heated with stirring at 190–200°C for 3 h, left to cool, and triturated with ethanol. The solid product that formed was collected by filtration and recrystallized from a proper solvent to give **3a** and **3b**.

3a; Yield, 68% (benzene); m.p. 220–222°C; IR: $\nu = 3340, 3290$ (NH_2), 3170 (NH), 2225 (C≡N), 1670 cm^{-1} (CO); ^1H NMR (DMSO-d_6): $\delta = 2.11$ (s, 3H, CH_3), 5.51 (br s, 2H, NH_2), 7.15–8.23 (m, 13H, ArH and NH); Anal. calcd. for $C_{29}H_{18}N_6OS$ (498.56): C, 69.86; H, 3.64; N, 16.86%. Found: C, 69.51; H, 3.42; N, 16.98%.

3b; Yield, 65% (dioxane); m.p. 23–233°C; IR: $\nu = 3350, 3280$ (NH_2), 3190 (NH), 1725, 1670 (2CO), 1610–1605 cm^{-1} (CN); ^1H NMR (DMSO-d_6): $\delta = 1.35$ (t, 3H, CH_3), 2.15 (s, 3H, CH_3), 4.11 (q, 2H, CH_2), 5.62 (br s, 2H, NH_2), 7.16–8.35 (m, 13H, ArH and NH); Anal. calcd. for $C_{31}H_{23}N_5O_3S$ (545.61): C, 68.24; H, 4.25; N, 12.84%. Found: C, 68.56; H, 4.53; N, 12.51%.

5-Amino-4-(dibenzothiophen-2-yl)-3-methyl-1,7-diphenyl-1H-pyrazolo[3,4-b][1,8]-naphthyridine-6-carbonitrile (4a) and 5-Amino-7-(4-chlorophenyl)-4-(dibenzo-thiophen-2-yl)-3-methyl-1-phenyl-1H-pyrazolo[3,4-b][1,8]naphthyridine-6-carbonitrile (4b)

A suspension of **2** (5 mmol) and arylidenemalononitrile (5 mmol) in dioxane (30 mL) containing sodium metal (0.69 g) was heated under reflux for 3 h. The reaction mixture was poured onto ice-cold water and then neutralized by diluted HCl. The solid product formed was collected by filtration and recrystallized from a suitable solvent to give **4a** and **4b**.

4a; Yield, 79% (ethanol); m.p. 196–198°C; IR: $\nu = 3390$, 3275 (NH_2), 22215 cm^{-1} (C≡N); ^1H NMR ($CDCl_3$): $\delta = 2.11$ (s, 3H, CH_3), 5.89 (br s, 2H, NH_2), 7.19–8.12 (m, 17H, ArH); ^{13}C NMR: $\delta = 13.95$ (CH_3), 110.8 (C-3a), 116.7 (C-4a), 123.2 (CN), 130.1 (C-9a), 150.3 (C-4), 155.3 (C-3), 158.7 (C-8a), 163.2 (C-6), 165.3 (C-7), 114.6, 114.9, 124.3, 124.9, 125.3, 125.8 (C— phenyl attached to pyrazole ring), 122.4, 125.3, 127.8, 129.1, 130.2, 130.9, 131.9, 132.7, 134.5, 135.8, 136.7, 138.5 (C— of dibenzothiophene), 124.3, 126.2, 126.3, 128.3, 128.5, 141.3 (C— phenyl attached to pyridine ring); Anal. calcd. for $C_{35}H_{22}N_6S$ (558.66): C, 75.25; H, 3.97; N, 15.04%. Found: C, 75.53; H, 3.71; N, 15.27%.

4b; Yield, 75% (ethanol); m.p. 201–203°C; IR: $\nu = 3380$, 3285 (NH_2), 2221 (C≡N), 1620–1610 cm^{-1} (C=N); MS: m/z: 593 (M^+); Anal. calcd. for $C_{35}H_{21}ClN_6S$ (593.10): C, 70.88; H, 3.57; N, 14.17%. Found: C, 70.50; H, 3.42; N, 14.36%.

[4-(Dibenzothiophen-2-yl)-7,8-dihydro-3-methyl-1-phenyl-7-thioxo-1H-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-5-yl]thiourea (5)

To a solution of **2** (5 mmol) in acetic acid (20 mL), ammonium thiocyanate (15 mmol) was added, and the reaction mixture was refluxed for 10 h. The solid product that formed after cooling and dilution with water was filtered off and recrystallized from dioxane to give **5**. Yield, 62%; m.p. 246–248°C; IR: $\nu = 3390$–3180 (multiple bands, NH_2, NH), 1260–1250 cm^{-1} (2CS); MS: m/z: 549 (M^+); Anal. calcd. for $C_{28}H_{19}N_7S_3$ (549.70): C, 61.18; H, 3.48; N, 17.84%. Found: C, 61.43; H, 3.62; N, 17.60%.

4-(Dibenzothiophen-2-yl)-1,8-dihydro-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclo-penta[b]naphthalene-5,7-dithione (6)

To a solution of **2** (6 mmol) in DMF (25 mL), carbon disulfide (9 mmol), and sodium methoxide (10 mL) (prepared from 0.56 g of sodium metal in 20 mL of methanol) were added. The reaction mixture was refluxed for 15 h, and then poured into ice-cold water. A solution of sodium hydroxide (10 mL, 1M) was added to it and left overnight. The solution was filtered off and acidified with dilute acetic acid (10 mL) to give the solid product, which was collected, washed with dilute acetic acid, dried, and recrystallized from dioxane to give **6**. Yield, 46%; m.p. 247–249°C; IR: $\nu = 3390$–3325 (2NH), 1265–1255 cm^{-1} (2CS); ^1H NMR (DMSO-d_6): $\delta = 2.15$ (s, 3H, CH_3), 7.12–8.11 (m, 12H, ArH), 8.51, 8.77 (2s, 2H, 2NH, exchangeable); Anal. calcd. for $C_{27}H_{17}N_5S_3$ (507.66): C, 63.88; H, 3.38; N, 13.80%. Found: C, 63.58; H, 3.14; N, 13.98%.

4-(Dibenzothiophen-2-yl)-1,5,6,8-tetrahydro-5-imino-3-methyl-1,6-diphenyl-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-7-one (7a) and 4-(Dibenzothiophen-2-yl)-1,5,6,8-tetrahydro-5-imino-3-methyl-1,6-diphenyl-1,2,6,8,9-pentaazacyclopenta[b]naphthalene-7-thione (7b)

A mixture of **2** (5 mmol) and phenyl isocyanate (5 mmol) or phenyl isothiocyanate (5 mmol) in pyridine (20 mL) was heated under reflux for 5 h. The reaction mixture was cooled and poured onto ice-cold water and neutralized with diluted HCl. The solid product so formed was collected by filtration and recrystallized from a proper solvent to give **7a** and **7b**.

7a; Yield, 76% (ethanol); m.p. 251–253°C; IR: $\nu = 3390, 3320$ (2NH), 1670 cm^{-1} (CO); ^1H NMR ($CDCl_3$): $\delta = 2.18$ (s, 3H, CH_3), 6.99–8.11 (m, 17H, ArH), 8.34, 9.11 (2H, 2NH, exchangeable); Anal. calcd. for $C_{33}H_{22}N_6OS$ (550.63): C, 71.98; H, 4.03; N, 15.26%. Found: C, 71.62; H, 3.85; N, 15.43%.

7b; Yield, 69% (benzene); m.p. 236–238°C; IR: $\nu = 3380, 3230$ (2NH), 1255 cm^{-1} (CS); MS: m/z: 566 (M^+); Anal. calcd. for $C_{33}H_{22}N_6S_2$ (566.70): C, 69.94; H, 3.91; N, 14.83%. Found: C, 69.62; H, 3.65; N, 14.99%.

4-(Dibenzothiophen-2-yl)-1,6-dihydro-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclo-penta[b]naphthalene-5-one (8)

A mixture of **2** (5 mmol) and formic acid (5 mL, 85%) was heated under reflux for 6 h. The reaction mixture was cooled, and the solid formed was collected by filtration, dried, and recrystallized from acetic acid to give **8**. Yield, 51%; m.p. 262–264°C; IR: $\nu = 3375$ (NH), 1675 cm^{-1} (CO); ^1H NMR ($CDCl_3$): $\delta = 2.13$ (s, 3H, CH_3), 7.11–8.23 (m, 14H, ArH, 1H of pyrimidine and NH); Anal. calcd, for $C_{27}H_{17}N_5OS$ (459.52): C, 70.57; H, 3.73; N, 15.24%. Found: C, 70.73; H, 3.85; N, 15.10%.

4-(Dibenzothiophen-2-yl)-3-methyl-1-phenyl-1H-1,2,6,8,9 pentaazacyclopenta[b]naphthalen-5-ylamine (9)

A mixture of **2** (5 mmol) and formamide (10 mL) was heated under reflux for 10 h. The solid that separated on cooling was filtered off and recrystallized from *n*-butanol to give **9**. Yield, 73%; m.p. 302–304°C; IR: $\nu = 3405, 3350$ (NH_2), 1615–1605 cm^{-1} (CN); ^1H NMR ($CDCl_3$): $\delta = 2.12$ (s, 3H, CH_3), 5.91 (br s, 2H, NH_2), 7.15–8.23 (m, 13H, ArH and 1H of pyrimidine); Anal. calcd. for $C_{27}H_{18}N_6S$ (458.54): C, 70.72; H, 3.96; N, 18.33%. Found: C, 70.52; H, 3.63; N, 18.54%.

General Procedure for Preparation of Compounds 10a–c

A mixture of compound **2** (4 mmol) and urea (8 mmol), thiourea (8 mmol), or guanidine hydrochloride (8 mmol) was heated in an oil bath at 180°C for 30 min and then continued for another 2 h at 190°C. The molten product was boiled with water, cooled, filtered off, and recrystallized from a suitable solvent to give **10a–c**.

5-Amino-4-(dibenzothiophen-2-yl)-1,8-dihydro-3-methyl-1-phenyl-1,2,6,8,9-pentaaza-cyclopenta[b]naphthalen-7-one (10a)

Yield, 52% (benzene); m.p. 243–245°C; ν = 3410–3190 (NH_2/NH), 1670 cm^{-1} (CO); ^1H NMR ($CDCl_3$): $\delta = 2.14$ (s, 3H, CH_3), 5.96 (br s, 2H, NH_2), 6.99–8.24 (m, 13H, ArH and NH, exchangeable); Anal. calcd. for $C_{27}H_{18}N_6OS$ (474.54): C, 68.34; H, 3.82; N, 17.71%. Found: C, 68.64; H, 3.96; N, 17.51%.

5-Amino-4-(dibenzothiophen-2-yl)-1,8-dihydro-3-methyl-1-phenyl-1,2,6,8,9-pentaaza-cyclopenta[b]naphthalene-7-thione (10b)

Yield, 53% (dioxane); m.p. 271–273°C; IR: ν = 3390–3200 (NH_2/NH), 1245 cm^{-1} (CS); Anal. calcd. for $C_{27}H_{18}N_6S_2$ (490.60): C, 66.10; H, 3.70; N, 17.13%. Found: C, 66.36; H, 3.95; N, 17.32%.

4-(Dibenzothiophen-2-yl)-7,8-dihydro-7-imino-3-methyl-1-phenyl-1H-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-5-ylamine (10c)

Yield, 56% (DMF-H_2O, 3:1); m.p. 256–258°C; ν = 3420–3210 (NH_2/NH), 1610–1600 cm^{-1} (CN); MS: m/z: 473 (M^+); Anal. calcd. for $C_{27}H_{19}N_7S$ (473.55): C, 68.48; H, 4.04; N, 20.70%. Found: C, 68.63; H, 4.25; N, 20.46%.

5-(Benzoxazol-2-yl)-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1H-pyrazolo[3,4-b]-pyridin-6-ylamine (11)

A mixture of **2** (5 mmol) and *o*-aminophenol (5 mmol) in absolute ethanol (25 mL) containing a few drops of pyridine was refluxed for 15 h. The solid product so obtained after cooling was collected by filtration and recrystallized from ethanol to give **11**. Yield, 73%; m.p. 236–238°C; IR: ν = 3410, 3270 (NH_2), 1610–1600 cm^{-1} (CN); ^1H NMR ($CDCl_3$): $\delta = 2.11$

(s, 3H, CH_3), 5.89 (br s, 2H, NH_2), 7.13–8.31 (m, 16H, ArH); ^{13}C NMR: $\delta = 13.87$ (CH_3), 111.3 (C-3a), 120.1 (C-5), 131.8 (C-7a), 150.2 (C-4), 154.3 (C-3), 155.7 (C-6), 164.3 (C-2 of benzoxazole), 120.1, 120.3, 131.1, 131.3, 133.2, 140.3 (C- phenyl attached to pyrazole ring), 118.1, 121.3, 124.8, 126.1, 127.7, 129.3, 130.2, 131.6, 132.7, 134.8, 135.1, 137.2 (C-dibenzothiophene group), 115.8, 128.4, 130.1, 134.2, 144.1, 153.8 (C— of benzoxazole); Anal. calcd. for $C_{32}H_{21}N_5OS$ (523.61): C, 73.40; H, 4.04; N, 13.38%. Found: C, 73.15; H, 4.34; N, 13.10%.

Ethyl N-[5-cyano-4-(dibenzothiophen-2-yl)-3-methyl-1-phenyl-1H-pyrazolo[3,4-b]-pyridin-6-yl]formimidate (12)

A mixture of **2** (20 mmol), triethyl orthoformate (10 mL), and acetic anhydride was heated under reflux for 6 h, cooled, and poured onto cold water. The formed solid product was collected by filtration and dried to give **12**. Yield, 63%; m.p. 236–238°C; IR: $\nu = 2225$ (C≡N), 1615–1650 cm^{-1} (CN).

The General Procedure for Preparation the Compounds 13a, b

A mixture of **12** (5 mmol) and the appropriate amine (5 mmol) in absolute ethanol (20 mL) was refluxed for 12 h. The reaction mixture was poured onto ice-cold water and neutralized with diluted hydrochloric acid (10 ml). The solid a product was filtered off, dried, and recrystallized from a proper solvent to give **13a**, **b**.

4-(Dibenzothiophen-2-yl)-1,6-dihydro-3,6-dimethyl-1-phenyl-1,2,6,8,9-pentaaza-cyclopenta[b]naphthalen-5-ylideneamine (13a)

Yield, 63% (benzene); m.p. 226–228°C; IR: $\nu = 3210$ (NH), 1610–1600 cm^{-1} (CN); Anal. calcd. for $C_{28}H_{20}N_6S$ (472.56): C, 71.16; H, 4.27; N, 17.78%. Found: C, 71.33; H, 4.52; N, 17.53%.

6-Benzyl-4-(dibenzothiophen-2-yl)-1,6-dihydro-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-5-ylideneamine (13b)

Yield, 56% (n-butanol); m.p. 201–203°C; IR: $\nu = 3190$ (NH), 1615–1610 cm^{-1} (CN); ^1H NMR ($CDCl_3$): $\delta = 2.12$ (s, 3H, CH_3), 4.11 (s, 2H, CH_2), 7.10–8.23 (m, 18H, ArH and 1H of pyrimidine), 8.95 (s, 1H, NH, exchangeable); Anal. calcd. for $C_{34}H_{24}N_6S$ (548.66): C, 74.43; H, 4.41; N, 15.32%. Found: C, 74.12; H, 4.22; N, 15.60%.

4-(Dibenzothiophen-2-yl)-1,5-dihydro-5-imino-3-methyl-1-phenyl-1,2,6,8,9-pentaazacyclopenta[b]naphthalen-6-ylamine (14)

To a well-stirred cold solution of compound **12** (20 mmol) in ethanol (20 mL), hydrazine hydrate (3 mL) was added for 1 h, and then the reaction mixture was stirred at r.t. for 7 h and left overnight. The solid that precipitated was filtered off and recrystallized from ethanol to give **14**. Yield, 74%; m.p. 252–254°C; IR: ν = 3375–3210 (NH_2/NH), 1610–1600 cm^{-1} (CN); ^1H NMR ($CDCl_3$): δ = 2.13 (s, 3H, CH_3), 5.90 (br s, 2H, NH_2), 7.12–8.13 (m, 13H, ArH and 1H of pyrimidine), 9.12 (s, 1H, NH, exchangeable); Anal. calcd. for $C_{27}H_{19}N_7S$ (473.55): C, 68.48; H, 4.04; N, 20.70%. Found: C, 68.63; H, 4.26; N, 20.48%.

11-(Dibenzothiophen-2-yl)-10-methyl-8-phenyl-8H-1,3,4,6,7,8,9-heptaazadicyclo-penta[a,g]naphthalene-2-thione (15)

To a solution of **14** (5 mmol) in absolute ethanol (25 mL), carbon disulfide (3 mL) was added. The reaction mixture was heated on a water bath for 5 h. The solid formed was collected by filtration, dried, and recrystallized from DMF-H_2O (3:1) to give **15**. Yield, 58%; m.p. 201–203°C; IR: ν = 3250 (NH), 1245 cm^{-1} (CS); ^1H NMR ($CDCl_3$): δ = 2.11 (s, 3H, CH_3), 6.95–8.11 (13H, ArH, and 1H of pyrimidine), 8.96 (s, 1H, NH, exchangeable); Anal. calcd. for $C_{28}H_{17}N_7S_2$ (515.61): C, 65.22; H, 3.32; N, 19.02%. Found: C, 65.10; H, 3.12; N, 19.25%.

The General Procedure for Preparation the Compounds 16a, b

A mixture of **14** (5 mmol) and an excess of the appropriate carboxylic acids (12 mL) was refluxed for 8 h. The reaction mixture was cooled and poured onto ice-cold water. The solid product formed was collected by filtration, dried, and recrystallized from a suitable solvent to give **16a**,**b**.

11-(Dibenzothiophen-2-yl)-10-methyl-8-phenyl-8H-1,3,4,6,7,8,9-heptaazadicyclo-penta[a,g]naphthalene (16a)

Yield, 55% (dioxane); m.p. 195–197°C; IR: ν = 1620–1610 cm^{-1} (CN); ^1H NMR ($CDCl_3$): δ = 2.12 (s, 3H, CH_3), 7.12–8.11 (m, 14H, ArH, 1H of pyrimidine and 1H of triazole); Anal. calcd. for $C_{28}H_{17}N_7S$ (483.55): C, 69.55; H, 3.54; N, 20.28%. Found: C, 69.30; H, 3.22; N, 20.45%.

11-(Dibenzothiophen-2-yl)-2,10-dimethyl-8-phenyl-8H-1,3,4,6,7,8,9-heptaazadicyclo-penta[a,g]naphthalene (16b)

Yield, 51% (dioxane); m.p. 212–214°C; IR: ν = 1615–1605 cm^{-1} (CN); MS: m/z: 497 (M^+); Anal. calcd. for $C_{29}H_{19}N_7S$ (497.57): C, 70.00; H, 3.85; N, 19.71%. Found: C, 70.23; H, 3.96; N, 19.48%.

11-[(Dibenzothiophen-2-yl)-10-methyl-8-phenyl-8H-1,3,4,6,7,8,9-heptaazadicyclo-penta[a,g]naphthalene-2-yl]acetonitrile (17)

A mixture of **14** (5 mmol) and ethyl cyanoacetate (7 mmol) in absolute ethanol (40 mL) was refluxed for 8 h. The solid formed after cooling was filtered off and recrystallized from ethanol to give **17**. Yield, 58%; m.p. 231–233°C; IR: ν = 2220 (C≡N), 1615–1605 cm^{-1} (C=N); ^{1}H NMR ($CDCl_3$): δ = 2.13 (s, 3H, CH_3), 4.12 (s, 2H, CH_2), 7.10–8.15 (m, 13H, ArH and 1H of pyrimidine); Anal. calcd. for $C_{30}H_{18}N_8S$ (522.58): C, 68.95; H, 3.47; N, 21.44%. Found: C, 68.70; H, 3.22; N, 21.65%.

12-(Dibenzothiophen-2-yl)-11-methyl-9-phenyl-9H-1,4,5,7,8,9,10-heptaazacyclo-penta[b]phenanthrene-2,3-dione (18)

To a solution of **14** (5 mmol) in dry benzene (25 mL), oxalyl chloride (4 mL) was added, and the reaction mixture was refluxed for 10 h. After cooling, the solid product was collected by filtration, dried, and recrystallized from *n*-butanol to give **18**. Yield, 61%; m.p. 191–193°C; IR: ν = 3220 (NH), 1675–1670 cm^{-1} (2CO); ^{1}H NMR ($CDCl_3$): δ = 2.11 (s, 3H, CH_3), 7.12–8.20 (m, 14H, ArH, 1H of pyrimidine and NH); Anal. calcd. for $C_{29}H_{17}N_7O_2S$ (527.56): C, 66.02; H, 3.25; N, 18.59%. Found: C, 66.23; H, 3.42; N, 18.31%.

12-(Dibenzothiophen-2-yl)-2,9-dihydro-11-methyl-9-phenyl-1,4,5,7,8,9,10-heptaaza-cyclopenta[b]phenanthren-3-one (19)

A mixture of **14** (5 mmol) and chloroacetyl chloride (5 mmol) in dry dioxane (30 mL) was allowed to stand at r.t. overnight. The formed precipitate was filtered off and recrystallized from dioxane to give **19**. Yield, 56%; m.p. 213–215°C; IR: ν = 3210 (NH), 1670 cm^{-1} (CO); MS: m/z: 513 (M^+); Anal. calcd. for $C_{29}H_{19}N_7OS$ (513.57): C, 67.82; H, 3.73; N, 19.09%. Found: C, 67.51; H, 3.52; N, 19.28%.

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