Microwave-Assisted Synthesis of Bis(enaminoketones): Versatile Precursors for Novel Bis(pyrazoles) *via* Regioselective 1,3-Dipolar Cycloaddition with Nitrileimines

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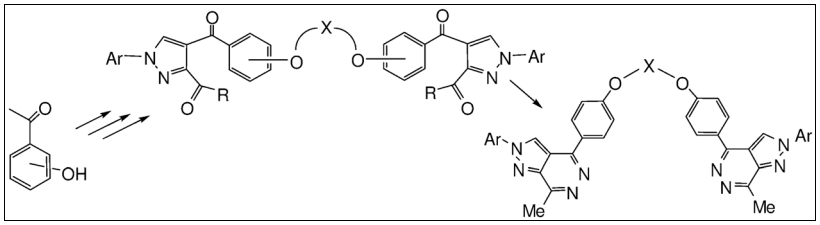

Synthesis of bis(enaminones) **6a–c** and **7a–c** was accomplished by the reaction of bis(acetophenones) **3a–c** and **4a–c** with dimethylformamide–dimethylacetal, under microwave irradiation. 1,3-Dipolar cycloaddition of bis(enaminones) **6a** and **7b,c** with nitrileimines in refluxing benzene led to the regioselective synthesis of the novel bis(pyrazoles) **11a–h** in 62–89% yield. The bis(pyrazoles) **11b,c** underwent condensation with hydrazine hydrate to give the corresponding bis(pyrazolo[3,4-*d*]pyridazines) **14a,b** in good yields.

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INTRODUCTION

Enaminones are interesting compounds not only for their therapeutic and pharmacological potentialities but also for being valuable intermediates for the synthesis of several heterocyclic systems [1–11]. Moreover, compounds containing pyrazole moiety exhibit a wide range of biological activities [12–18]. These include blockbuster drugs such as Celebrex [19] and Viagra [20]. Recently, the activity of a series of pyrazole as inhibitors of p38 mitogen-activated protein kinase has been reported [21]. The large applications of such heterocycles in pharmaceutical [22] as well as in agrochemical industry [23] have made them popular synthetic targets [24].

Furthermore, bis-heterocyclic compounds with a suitable alkyl spacer constitute an important class of compounds, and their various types of activities, especially, as antitumor [25] and as antimicrobial [26], have been studied. These activities, which result in their pharmacological utility, have been reported to be enhanced when different functionalities or substitutions are present on the two heterocyclic moieties in the bis-compound [27–36].

Moreover, the use of microwave irradiation in chemical reaction enhancement has attracted much attention in the last decades [37–43]. The use of microwave heating has been shown to dramatically reduce reaction times, increase product yields, and enhance product purities by reducing unwanted side reactions compared with conventional heating methods.

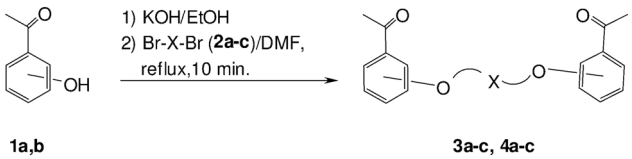
Keeping the above facts in mind and in continuation of our interest in the synthesis and chemistry of novel enaminones [44–52] as well as bis(hetrocycles) [53–60], we report herein a simple and efficient route for the synthesis of novel bis(enaminones) under pressurized microwave irradiation. The synthetic utilities of the new bis(enaminones) as key intermediates for the synthesis of novel bis(pyrazoles) were also investigated.

RESULTS AND DISCUSSION

To synthesize the target bis(enaminones) **6a–c** and **7a–c,** our attention was focused on bis(acetophenones) **3** and **4** as precursors, which could be obtained by the reaction of the potassium salt of 4-hydroxyacetophenones **1a,b** with the appropriate dibromoalkanes **2a–c** in boiling dimethylformamide (DMF) (Scheme 1).

Treatment of **3a–c** or **4a–c** with dimethylformamide–dimethylacetal (DMF–DMA) (**5**) (Scheme 2) under solvent-free conditions and microwave irradiation using pressurized conditions (249 psi, 120°C, 20–30 min; method B) afforded the crystalline products that were identified as the bis(enaminones) **6a–c** or **7a–c** in excellent yields. When the condensation of **3a–c** or **4a,b** with DMF–DMA was carried out under conventional heating conditions (method A), the corresponding bis(enaminones) **6a–c** or **7a–c** were obtained in 5–80% yield and the reaction time exceeded 10 h (Table 1). It is noteworthy to mention that

Scheme 1



enaminones **7b,c** were recently obtained in 62 and 57% yields, respectively, by heating **4b,c** with DMF–DMA (Scheme 2) under reflux conditions for 10 h [61].

The structure of the bis(enaminones) **6** and **7** was established on the basis of their elemental analysis and spectral data. The ^{1}H-NMR spectrum of **6a** as a representative example, displayed a singlet at δ 2.94 due to *N*,*N*-dimethyl protons, a singlet at δ 4.38 due to methylene group, two doublets at δ 5.75 and 7.44 (J = 11.7 Hz) due to olefinic protons, besides the aromatic multiplet at δ 6.95–7.50. The value of the coupling constant (J = 11.7 Hz) for the ethylenic protons indicates that the bis(enaminone) **6** or **7** exists exclusively in the *E*-configuration.

The now available, bis(enaminones) prompted us to study their synthetic utilities as building blocks for novel bis(pyrazoles) *via* 1,3-dipolar cycloaddition with nitrilimines. Thus, the reaction of the bis(enaminones) **6a** and **7b,c** with the nitrilimines **9** (generated *in situ* by the action of triethylamine on the hydrazonoyl chloride **8**) in dry benzene at room temperature afforded a single product (as examined by thin layer chromatography (TLC) and ^{1}H-NMR spectroscopy) for which the two regioisomeric cycloadducts **11** and **13** seemed possible (Scheme 3). However, the regioisomers **11** were assigned for the reaction products on the basis of their ^{1}H-NMR spectra. For example, the ^{1}H-NMR spectrum of **11a** revealed two singlets at δ 2.43 and δ 3.74 due to acetyl-CH_3 and OCH_2 protons, respectively, a characteristic singlet at δ 8.69 due to pyrazole-5-CH protons in addition to the multiplet signals of the aromatic protons at δ 6.70–7.71. The presence of a singlet at δ 8.69 as well as the absence of any signals around δ 5–6 ppm due to a =CH−C protons of pyrazole ring confirms the existence of regioisomers **11** and rules out the other alternative structure **13**.

The formation of the 5-unsubstituted bis (pyrazoles) **11** is assumed to take place *via* a regioselective 1,3-cycloaddition of the nitrilimine intermediate **9** to the activated double bond of the bis(enaminone) **6** or **7** to form the nonisolable intermediate **10**, followed by elimination of dimethylamine under the reaction conditions.

Table 1

Comparative study for the synthesis of bis(enaminones) **6a–c** and **7a–c** under microwave irradiation and conventional heating.

6a-c (*o*-isomer)	X	Yield % (time) Method A[a]	Yield % Method B[b]
a	$(CH_2)_2$	5 (20h)	96
b	$(CH_2)_3$	34 (10h)	84
c	$(CH_2)_4$	80 (10h)	89
7 a-c (*p*-isomer)			
a	$(CH_2)_2$	27 (10h)	91
b	$(CH_2)_3$	43 (62)[61] (10h)	90
c	$(CH_2)_4$	33 (57)[61] (10h)	93

[a]**Method A**: Δ, neat.
[b]**Method B**: MW, 300W, 20–30 min

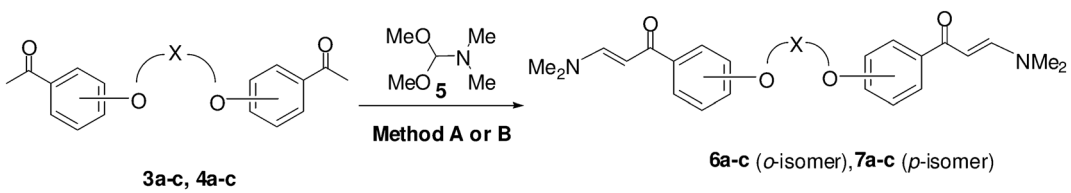
As further confirmation of the regiochemistry of **11** comes from its reaction with hydrazine hydrate to afford a high yield of a yellow-colored product, which was identified as the bis(pyrazolo[3,4-*d*]pyridazinea) **14a,b** (Scheme 4). The IR spectra of compounds **11b** or **11c** showed two carbonyl absorption bands in the region of 1689–1642 cm^{-1}, which disappeared in the IR spectrum of the bis(pyrazolo[3,4-*d*] pyridazine) products **14a,b**.

In conclusion, we developed an efficient synthetic route for a series of novel bis(enaminones) under microwave irradiation and solvent-free conditions. The synthetic utility of these compounds as building blocks for novel bis(pyrazoles) has been achieved *via* regioselective 1,3-dipolar cycloaddition with nitrilimines. The structure of the new compounds was confirmed by spectral data as well as by chemical reactions. The novel starting bis(enaminones) would open a new access to a variety of heterocyclic systems with possible pharmaceutical properties. The new synthesized bis (fused heterocycles) offer an advantage of their easy synthesis from inexpensive starting materials, and we believe that they should be useful compounds with potentially high pharmacological and biological activities.

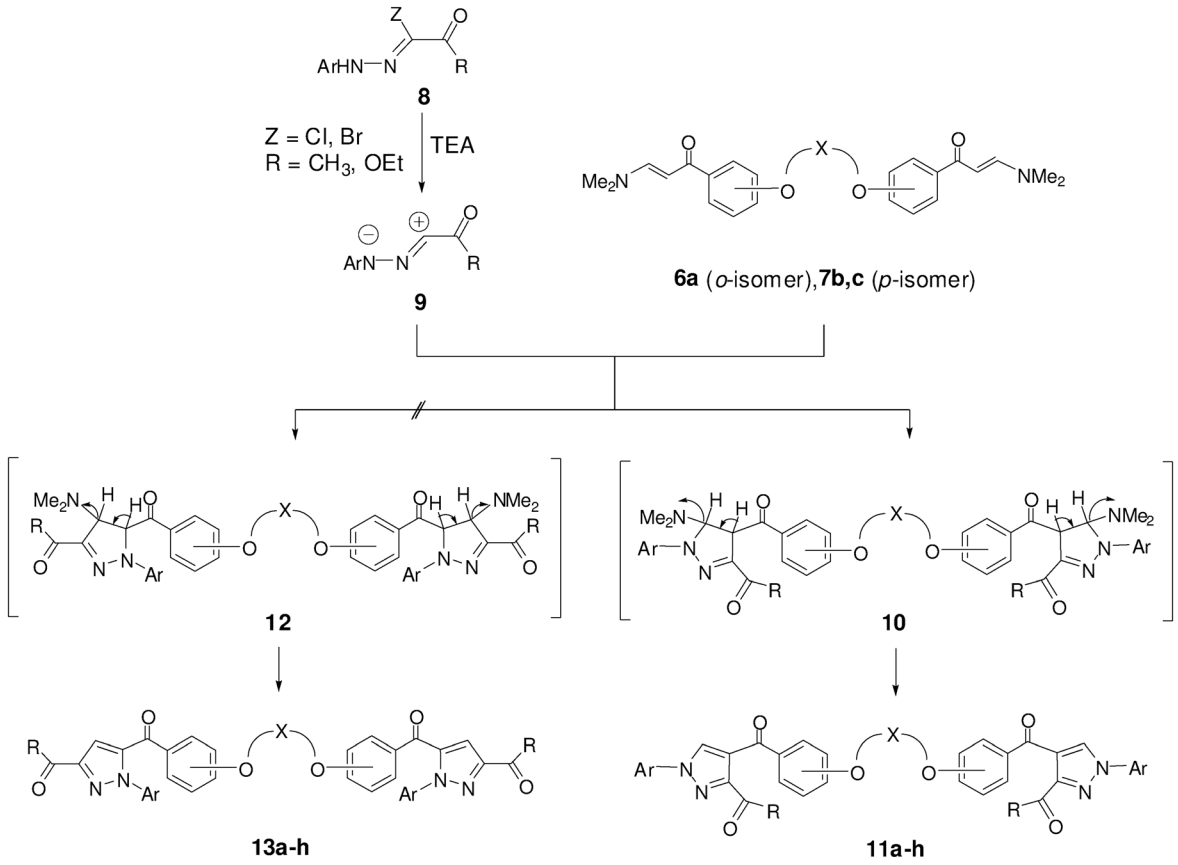
EXPERIMENTAL

Melting points were measured on a Gallenkamp melting point apparatus. IR spectra were recorded on a Shimadzu FT-IR 8101 PC infrared spectrophotometer. The ^{1}H-NMR and ^{13}C-NMR spectra were determined in dimethyl sulfoxide (DMSO-d_6) on a Varian Mercury VX 300 NMR spectrometer (^{1}H at 300 MHz and ^{13}C at 75 MHz) using tetramethylsilane (TMS) as an internal standard. Mass spectra were recorded on a Shimadzu GCMS-QP

Scheme 2

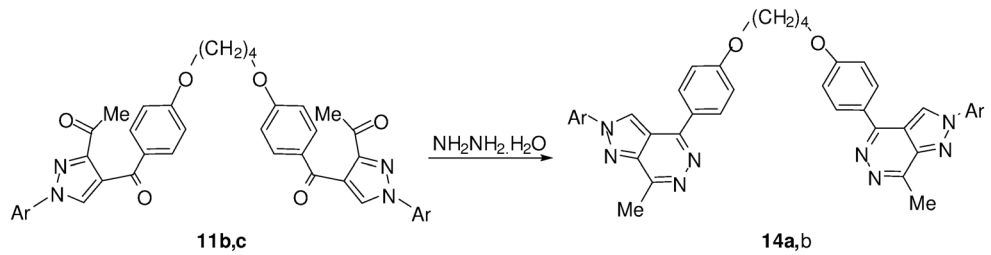


Scheme 3



11	X	R	Ar
11a (*o*-isomer)	$(CH_2)_2$	CH_3	C_6H_4Cl-*m*
11b-h (*p*-isomer)			
b	$(CH_2)_4$	CH_3	C_6H_4Me-*m*
c	$(CH_2)_4$	CH_3	C_6H_4Cl-*m*
d	$(CH_2)_4$	CH_3	$C_6H_4NO_2$-*m*
e	$(CH_2)_4$	OEt	$C_6H_4NO_2$-*m*
f	$(CH_2)_3$	CH_3	C_6H_4Me-*m*
g	$(CH_2)_3$	CH_3	C_6H_4Cl-*m*
h	$(CH_2)_3$	CH_3	$C_6H_4NO_2$-*m*

Scheme 4



14a, Ar = C_6H_4Me-*m*
14b, Ar = C_6H_4Cl-*m*

1000 EX mass spectrometer at 70 eV. Elemental analyses were carried out at the Microanalytical Center of Cairo University, Giza, Egypt. Microwave experiments were carried out using CEM MARS synthator™ microwave apparatus. The hydrazonoyl halides **8a–g** [62] were prepared according to literature procedures.

Synthesis of 1,ω-bis(2-acetylphenoxy)alkanes 3a–c and 1,ω-bis(4-acetylphenoxy)alkanes 4a,b. 2-Hydroxyacetophenone **1a** or 4-hydroxyacetophenone **1b** (10 mmol) was dissolved in a hot ethanolic KOH solution (prepared by dissolving 0.56 g (10 mmol) of KOH in 10 mL of absolute ethanol), and the solvent was then removed *in vacuo*. The remaining material was dissolved in DMF (10 mL) and the appropriate dibromides (5 mmol) were added. The reaction mixture was refluxed for 10 min during which KBr was separated. The solvent was then removed *in vacuo*, and the remaining materials were poured onto crushed ice. The crude precipitate of bis(acetylphenoxy)alkanes **3a–c** and **4a,b** were recrystallized from ethanol [54,63].

Synthesis of bis(enaminones).

General procedure.

Method A. A mixture of the appropriate bis(acetylphenoxy) alkanes **3a–c** or **4a–c** (0.01 mol) and DMF–DMA (10 equiv) was heated under reflux for 8–18 h. The excess DMF–DMA was distilled off under reduced pressure. The residual viscous liquid was taken in petroleum ether (bp 60–80°C; 20 mL), and the resulting crystals were collected by filtration, washed thoroughly with ether, dried, and finally recrystallized from dry benzene or dioxane to afford the corresponding bis(enaminone) **6a–c** and **7a–c**.

Method B. The appropriate bis(acetylphenoxy)alkanes **3a–c** or **4a–c** (10 mmol) and DMF–DMA (20 mmol) were mixed in a process vial. The vial was capped properly and irradiated by microwaves using pressurized conditions (249 psi, 120 °C) for 20–30 min. The vial contents were taken in ether, collected by filtration, washed with ether, dried, and finally recrystallized from dioxane to afford the corresponding bis(enaminones) **6a–c** and **7a–c** in excellent yield (cf. 1). The physical and spectral data of the synthesized compounds **6a–c** and **7a–c** are listed below.

6a: mp. 156–158°C; IR: (potassium bromide) 1631 (C=O) cm^{-1}; ^{1}H-NMR: δ 2.94 (s, 12H), 4.38 (s, 4H), 5.75 (d, 2H, *J* = 11.7 Hz), 6.95 (t, 2H, *J* = 7 Hz), 7.08 (d, 2H, *J* = 8 Hz), 7.34 (t, 2H, *J* = 7 Hz), 7.44 (d, 2H, *J* = 11.7 Hz), 7.50 (d, 2H, *J* = 8 Hz); ^{13}C-NMR: δ 44.2, 67.3, 96.9, 112.8, 120.4, 129.6, 130.7, 131.0, 153.3, 156.2, 186.3; ms: *m/z* (%) 408 (3.3, M^+). Anal. calcd. for $C_{24}H_{28}N_2O_4$: C, 70.57; H, 6.91; N, 6.86. Found: C, 70.54; H, 6.96; N, 6.89.

6b: Orange oil; IR: (potassium bromide) 1641 (C=O) cm^{-1}; ^{1}H-NMR: δ 2.22–2.24 (m, 2H), 2.85 (s, 12H), 4.19 (s, 4H), 5.54 (d, 2H, *J* = 11 Hz), 6.89 (t, 2H, *J* = 7 Hz), 6.98 (d, 2H, *J* = 8 Hz), 7.26 (d, 2H, *J* = 7 Hz), 7.32 (d, 2H, *J* = 11 Hz), 7.43 (d, 2H, *J* = 8 Hz); ms: *m/z* (%) 422 (7.9, M^+). Anal. calcd. for $C_{25}H_{30}N_2O_4$: C, 71.07; H, 7.16; N, 6.63. Found: C, 71.14; H, 7.11; N, 6.66.

6c: mp. 110–112°C; IR: (potassium bromide) 1661 (C=O) cm^{-1}; ^{1}H-NMR: δ 1.78–1.90 (m, 4H), 2.75 (br, 6H), 3.02 (br, 6H), 4.05–4.12 (m, 4H), 5.50 (d, 2H, *J* = 12.6 Hz), 6.93 (d, 2H, *J* = 7 Hz), 7.02 (d, 2H, *J* = 8 Hz), 7.31 (t, 2H, *J* = 7 Hz), 7.34 (d, 2H, *J* = 12.3 Hz), 7.43 (d, 2H, *J* = 8 Hz); ^{13}C-NMR: δ 25.8, 44.2, 67.6, 97.0, 112.6, 120.0, 129.0, 130.5, 131.3, 153.3, 155.9, 186.2; ms: *m/z* (%) 436 (4.2, M^+). Anal. calcd. for $C_{26}H_{32}N_2O_4$: C, 71.53; H, 7.39; N, 6.42. Found: C, 71.48; H, 7.41; N, 6.39.

7a: mp. 231–233°C; IR: (potassium bromide) 1643 (C=O) cm^{-1}; ^{1}H-NMR: δ 3.01 (br, 6H), 3.17 (br, 6H), 4.39 (s, 4H), 5.76 (d, 2H, *J* = 12.3 Hz), 6.99 (d, 4H, *J* = 8 Hz), 7.62 (d, 2H, *J* = 12 Hz), 7.86 (d, 4H, *J* = 8 Hz); ms: *m/z* (%) 408 (5.3, M^+). Anal. calcd. for $C_{24}H_{28}N_2O_4$: C, 70.57; H, 6.91; N, 6.86. Found: C, 70.61; H, 6.88; N, 6.88.

7b: mp. 168–170°C [Lit mp. 170–172°C][61]; IR: (potassium bromide) 1642 (C=O) cm^{-1}; ^{1}H-NMR: δ 2.18–2.22 (m, 2H), 2.89 (br, 6H), 3.08 (br, 6H), 4.17–4.23 (m, 4H), 5.78 (d, 2H, *J* = 12 Hz), 6.96 (d, 4H, *J* = 8 Hz), 7.65 (d, 2H, *J* = 12 Hz), 7.85 (d, 4H, *J* = 8 Hz); ms: *m/z* (%) 422 (8.3, M^+). Anal. calcd. for $C_{25}H_{30}N_2O_4$: C, 71.07; H, 7.16; N, 6.63. Found: C, 71.01; H, 7.14; N, 6.59.

7c: mp. 204–206°C [Lit mp. 200–202°C][61]; IR: (potassium bromide) 1641 (C=O) cm^{-1}; ^{1}H-NMR: δ 2.02–2.23 (m, 4H), 2.91 (s, 6H), 3.08 (s, 6H), 4.19–4.23 (m, 4H), 5.78 (d, 2H, *J* = 12 Hz), 6.96 (d, 4H, *J* = 9 Hz), 7.65 (d, 2H, *J* = 12 Hz), 7.87–7 (d, 4H, *J* = 9 Hz); ms: *m/z* (%) 436 (21.2, M^+). Anal. calcd. for $C_{26}H_{32}N_2O_4$: C, 71.53; H, 7.39; N, 6.42. Found: C, 71.50; H, 7.43; N, 6.44.

Synthesis of bis(pyrazoles) 11a–h.

General procedure. To a mixture of bis(enaminones) **6a** or **7b,c** (0.02 mol) and the appropriate hydrazonyl halide 8 (0.02 mol), in benzene (25 mL), an equivalent amount of triethylamine was added. The reaction mixture was heated under reflux for 4 h, and the solvent was distilled off under reduced pressure. The residual brown viscous liquid was taken in methanol, and the resulting solid was collected by filtration, washed thoroughly with methanol, dried and finally recrystallized from ethanol/DMF to afford the corresponding bis(pyrazole) derivatives 11**a–h** in 62–89% yield.

11a: (74% yield), mp. 226–228°C; IR: (potassium bromide) 1696, 1648 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 2.43 (s, 6H), 3.74 (s, 4H), 6.70 (d, 2H, *J* = 8 Hz), 6.86 (t, 2H, *J* = 7 Hz), 7.25 (d, 2H, *J* = 7 Hz), 7.29 (t, 2H, *J* = 7 Hz), 7.42 (t, 2H, *J* = 8 Hz), 7.50 (d, 2H, *J* = 8 Hz), 7.63 (d, 2H, *J* = 7 Hz), 7.71 (s, 2H), 8.69 (s, 2H); ms: *m/z* (%) 707 (5.3, M^+). Anal. calcd. for $C_{38}H_{28}Cl_2N_4O_6$: C, 64.50; H, 3.99; N, 7.92. Found: C, 64.42; H, 4.05; N, 7.87.

11b: (89% yield), mp. 192–194°C; IR: (potassium bromide) 1689, 1643 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 1.90–1.93 (m, 4H), 2.41 (s, 6H), 2.56 (s, 6H), 4.14–4.21 (m, 4H), 7.01 (d, 4H, *J* = 9 Hz), 7.24 (d, 2H, *J* = 8 Hz), 7.42 (t, 2H, *J* = 8 Hz), 7.75–7.82 (m, 8H), 8.90 (s, 2H); ^{13}C-NMR: δ 20.9, 25.1, 27.0, 67.5, 114.2, 116.5, 119.8, 122.9, 128.5, 129.4, 130.1, 130.7, 131.5, 138.5, 139.4, 149.6, 162.7, 187.8, 192.5; ms: *m/z* (%) 694 (16.7, M^+). Anal. calcd. for $C_{42}H_{38}N_4O_6$: C, 72.61; H, 5.51; N, 8.06. Found: C, 72.55; H, 5.43; N, 8.11.

11c: (81% yield), mp. 240–242°C; IR: (potassium bromide) 1689, 1642 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 1.90–1.94 (m, 4H), 2.57 (s, 6H), 4.14–4.24 (m, 4H), 7.01 (d, 4H, *J* = 9 Hz), 7.51 (d, 2H, *J* = 7 Hz), 7.58 (t, 2H, *J* = 7 Hz), 7.77 (d, 4H, *J* = 9 Hz), 7.95 (d, 2H, *J* = 7 Hz), 8.09 (s, 2H), 9.00 (s, 2H); ms: *m/z* (%) 735 (11.4, M^+). Anal. calcd. for $C_{40}H_{32}Cl_2N_4O_6$: C, 65.31; H, 4.38; N, 7.62. Found: C, 65.35; H, 4.41; N, 7.61.

11d: (79% yield), mp. 276–278°C; IR: (potassium bromide) 1693, 1643 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 1.89–1.91 (m, 4H), 2.59 (s, 6H), 4.01–4.16 (m, 4H), 6.92 (d, 4H, *J* = 9 Hz), 7.79 (d, 4H, *J* = 9 Hz), 7.85 (t, 2H, *J* = 8 Hz), 8.25 (d, 2H, *J* = 8 Hz), 8.42 (d, 2H, *J* = 8 Hz), 8.77 (s, 2H), 9.12 (s, 2H); ms: *m/z* (%) 756 (22.2, M^+). Anal. calcd. for $C_{40}H_{32}N_6O_{10}$: C, 63.49; H, 4.26; N, 11.11. Found: C, 63.44; H, 4.32; N, 11.18.

11e: (62% yield), mp. 234–236°C; IR: (potassium bromide) 1728, 1643 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 1.08 (t, 6H, *J* = 6.9 Hz), 1.89–1.92 (m, 4H), 4.09–4.19 (m, 8H), 6.93 (d, 4H, *J* = 9

Hz), 7.84–7.89 (m, 6H), 8.26 (d, 2H, J = 8 Hz), 8.41 (d, 2H, J = 8 Hz), 8.75 (s, 2H), 9.23 (s, 2H); ms: m/z (%) 816 (2.5, M^+). Anal. calcd. for $C_{42}H_{36}N_6O_{12}$: C, 61.76; H, 4.44; N, 10.29. Found: C, 61.77; H, 4.47; N, 10.25.

11f: (68% yield), mp. 158–160°C; IR: (potassium bromide) 1681, 1630 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 2.13–2.23 (m, 2H), 2.41 (s, 6H), 2.56 (s, 6H), 4.22–4.24 (m, 4H), 7.04 (d, 4H, J = 9 Hz), 7.24 (d, 2H, J = 7.5 Hz), 7.42 (t, 2H, J = 7.5 Hz), 7.74–7.81 (m, 8H), 8.90 (s, 2H); ms: m/z (%) 680 (4.6, M^+). Anal. calcd. for $C_{41}H_{36}N_4O_6$: C, 72.34; H, 5.33; N, 8.23. Found: C, 72.36; H, 5.26; N, 8.28.

11g: (72% yield), mp. 214–216°C; IR: (potassium bromide) 1681, 1646 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 2.12–2.25 (m, 2H), 2.57 (s, 6H), 4.23–4.27 (m, 4H), 7.04 (d, 4H, J = 9 Hz), 7.49 (d, 2H, J = 8 Hz), 7.58 (t, 2H, J = 8 Hz), 7.78 (d, 4H, J = 9 Hz), 7.96 (d, 2H, J = 8 Hz), 8.10 (s, 2H), 9.00 (s, 2H); ^{13}C-NMR: δ 27.0, 28.2, 64.6, 114.3, 117.9, 119.1, 123.0, 127.6, 130.1, 131.2, 131.3, 131.6, 134.1, 139.7, 149.9, 162.5, 187.6, 192.5; ms: m/z (%) 721 (11, M^+). Anal. calcd. for $C_{39}H_{30}Cl_2N_4O_6$: C, 64.92; H, 4.19; N, 7.76. Found: C, 64.88; H, 4.23; N, 7.71.

11h: (63% yield), mp. 228–230°C; IR: (potassium bromide) 1674, 1645 (2 C=O) cm^{-1}; ^{1}H-NMR: δ 2.23–2.25 (m, 2H), 2.59 (s, 6H), 4.23–4.27 (m, 4H), 7.06 (d, 4H, J = 9 Hz), 7.81 (d, 4H, J = 8 Hz), 7.87 (t, 2H, J = 8 Hz), 8.26 (d, 2H, J = 8 Hz), 8.43 (d, 2H, J = 8 Hz), 8.78 (s, 2H), 9.16 (s, 2H); ms: m/z (%) 742 (11.9, M^+). Anal. calcd. for $C_{39}H_{30}N_6O_{10}$: C, 63.07; H, 4.07; N, 11.32. Found: C, 63.05; H, 4.11; N, 11.36.

Reaction of 11 with hydrazine. A mixture of the appropriate bis(pyrazole) **11b,c** (1 mmol) and hydrazine hydrate (98%; 2 mL, 10 mmol) was heated under reflux for 1 h, and then the mixture was left to cool at room temperature. The formed precipitates were collected by filtration, washed with ethanol, and dried. Recrystallization from DMF afforded yellow crystals of the corresponding bis(pyrazolo[3,4-*d*]pyridazine) derivatives **14a,b**.

14a: (90% yield), mp. 234–236°C; IR: (potassium bromide) 1604 (C=N) cm^{-1}; ^{1}H-NMR: δ 1.83–1.96 (m, 4H), 2.42 (s, 6H, CH_3), 2.82 (s, 6H, CH_3), 4.13–4.17 (m, 4H), 7.10 (d, 4H, J = 9 Hz), 7.30 (d, 2H, J = 8 Hz), 7.44 (t, 2H, J = 8 Hz), 8.14–8.17 (m, 8H), 9.50 (s, 2H); ms: m/z (%) 686 (28.6, M^+). Anal. calcd. for $C_{42}H_{38}N_8O_2$: C, 73.45; H, 5.58; N, 16.32. Found: C, 73.47; H, 5.54; N, 16.39.

14b: (83% yield), mp. >300°C; IR: (potassium bromide) 1608 (C=N) cm^{-1}; ^{1}H-NMR: δ 1.89–1.94 (m, 4H), 2.83 (s, 6H), 4.17–4.21 (m, 4H), 7.13 (d, 4H, J = 9 Hz), 7.60–7.68 (m, 4H), 8.16 (m, 6H), 8.34 (s, 2H), 9.64 (s, 2H); ms: m/z (%) 727 (28.6, M^+). Anal. calcd. for $C_{40}H_{32}Cl_2N_8O_2$: C, 66.03; H, 4.43; N, 15.40. Found: C, 66.08 H, 4.37; N, 15.33.

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