Synthesis of a New Library of Pyrano-phenazine Derivatives *via* a Novel Three-Component Protocol

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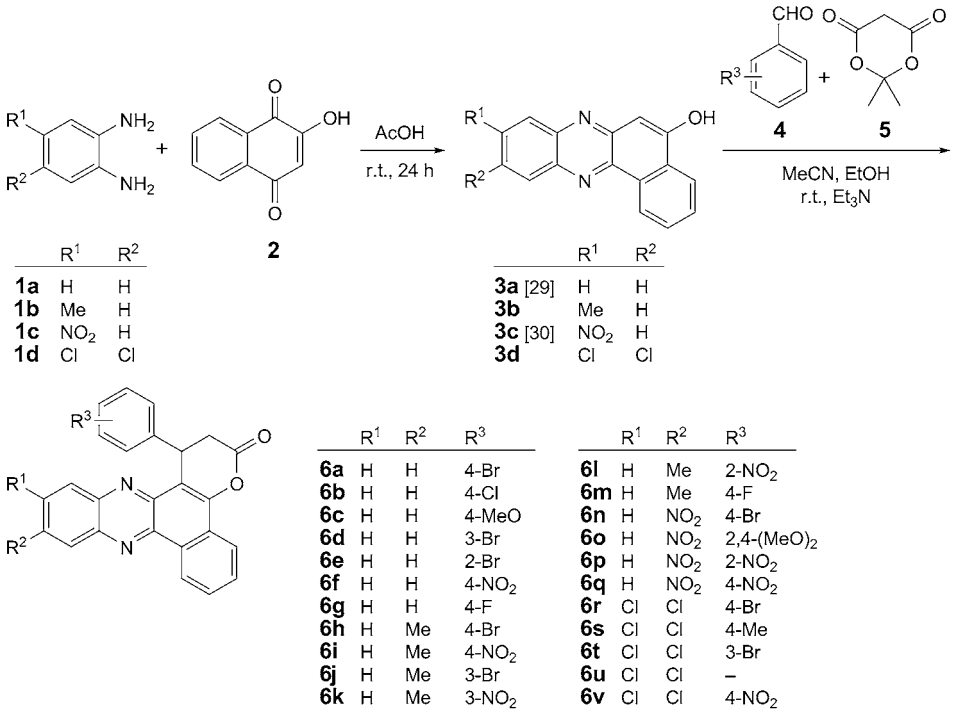
The pyrano-phenazine derivatives **6** were synthesized by an efficient procedure using the reaction between benzo[*a*]phenacin-5-ols with the condensation product of an aldehyde with *Meldrum*'s acid in the presence of a catalytic amount of Et_3N at ambient temperature. The procedure is very simple, and products could be separated from the reaction media by simple filtration. High functional-group tolerance both in the benzo[*a*]phenazin-5-ol and aldehyde moieties, facile reaction procedure, medium-to-high yields, and simple separation of the products from the reaction media are the advantages of this route.

Introduction. – Phenazines are among the important scaffolds, and they exhibit several biological features including cytotoxicity [1–6], genotoxicity [7], inhibition of the cyclooxygenase [8], interactions of serum albumins [9], antimicrobial activity [10], and anti-inflammatory activities [11]. These compounds are important because of their structural properties as well. Thermodynamic properties [12], molecular interaction of phenazine dyes with *Triton X-100* [13], reduction mechanism of phenazine [14], biosensors sensitive to H_2O_2, glucose, and lactose [15][16], and anion radical properties [17] of different phenazine derivatives have been studied. Because of the above mentioned properties, different methods for the synthesis of phenazines have been reported [6][18–25].

Results and Discussions. – Due to the biological and physical importance of the phenazine derivatives, and continuing our studies on multi-component reactions [26–28], herein we report a novel two-step procedure toward the synthesis of the 1-phenyl-1*H*-benzo[*a*]pyrano[2,3-*c*]phenazin-3(2*H*)-one derivatives. The first step consists in the condensation reaction between a diamine **1** and 1,4-dihydro-2-hydroxynaphthalene-1,4-dione (**2**) to afford benzo[*a*]phenazin-5-ols **3** [29][30] (*Scheme 1*). The latter were used as C-nucleophiles to react with the condensation product of aldehyde **4** with *Meldrum*'s acid (=2,2-dimethyl-1,3-dioxane-4,6-dione; **5**) to furnish the desired products **6a**–**6v**. The procedure is very simple, and the products could be separated from the reaction media by filtration with high purity and in high yields, and no further purification is needed (*Scheme 1*).

In a pilot experiment, benzene-1,2-diamine (**1a**) and **2** were stirred in AcOH for 24 h at room temperature to yield compound **3a** [29]. The product was separated and washed with H_2O to remove any acid residue. Then, **3** was added to a mixture of 4-bromobenzaldehyde (**4a**) and **5** in the presence of a catalytic amount of Et_3N in MeCN/

Scheme 1. *Synthesis of Products* **6a**–**6v**



	R^1	R^2
1a	H	H
1b	Me	H
1c	NO_2	H
1d	Cl	Cl

	R^1	R^2
3a [29]	H	H
3b	Me	H
3c [30]	NO_2	H
3d	Cl	Cl

	R^1	R^2	R^3
6a	H	H	4-Br
6b	H	H	4-Cl
6c	H	H	4-MeO
6d	H	H	3-Br
6e	H	H	2-Br
6f	H	H	4-NO_2
6g	H	H	4-F
6h	H	Me	4-Br
6i	H	Me	4-NO_2
6j	H	Me	3-Br
6k	H	Me	3-NO_2

	R^1	R^2	R^3
6l	H	Me	2-NO_2
6m	H	Me	4-F
6n	H	NO_2	4-Br
6o	H	NO_2	2,4-$(MeO)_2$
6p	H	NO_2	2-NO_2
6q	H	NO_2	4-NO_2
6r	Cl	Cl	4-Br
6s	Cl	Cl	4-Me
6t	Cl	Cl	3-Br
6u	Cl	Cl	–
6v	Cl	Cl	4-NO_2

EtOH 3 : 1 at room temperature. After 24 h, the precipitated product was separated by filtration and washed with H_2O (10 ml) and AcOEt (5 ml), and then recrystallized from EtOH/H_2O. Product **6a** was obtained as a yellow powder in 86% yield. The structure of the compound was deduced from the IR, ^{1}H- and ^{13}C-NMR, and MS data. For example, the ^{1}H-NMR spectrum of **6a** exhibited an *ABM* system as a broad *doublet* for the C*H*H at 3.20 ppm ($J = 16$), a *doublet* of *doublet* for the CH*H* at 3.68 ppm ($^2J = 18$, $^3J = 9$), a *doublet* for the CH at 5.53 ppm ($J = 9$), as well as two *doublet*s for the aromatic H-atoms at 7.26 and 7.45 ppm ($J = 6$), a *multiplet* for the seven aromatic H-atoms at 7.95–8.39 ppm, and a *doublet* at 9.36 ($J = 5$) for one aromatic H-atom.

To extend the chemical library, a variety of diamines **1** with an electron-releasing group (4-methylbenzene-1,2-diamine (**1b**)), an electron-withdrawing group (4-nitrobenzene-1,2-diamine (**1c**)), and halogen substituents (4,5-dichlorobenzene-1,2-diamine (**1d**)) were used instead of **1a** (*Scheme 1*). Also, reactions with different aldehydes with electron-withdrawing and electron-donating functional groups conducted to further extend the chemical library. The synthesized products **6a**–**6v** are presented in *Scheme 1*.

The effect of the solvent in the second step of the reaction has also been investigated. As indicated in *Table 1*, the reaction occurred very efficiently in mixed solvents MeCN/EtOH and MeCN/MeOH (*Entries 5* and *6*). In contrast, in the case of pure MeCN as a solvent, the reaction did not proceed efficiently because of the very

low solubility of the benzo[*a*]phenazin-5-ols **3**; when EtOH or DMF was used as a solvent, the reaction led to impure products and more purification steps were needed to obtain pure compounds, resulting in lower yields.

Table 1. *Effect of Solvents*[a])

Entry	Solvent	Ratio	Yield [%]
1	EtOH	–	25
2	MeOH	–	35
3	MeCN	–	10
4	DMF	–	42
5	MeCN/EtOH	3 : 1	86
6	MeCN/MeOH	3 : 1	90
7	MeCN/MeOH/DMF	3 : 1 : 1	68
8	MeCN/EtOH/DMF	3 : 1 : 1	85

[a]) 4-Bromobenzaldehyde (**4a**; 1 mmol), *Meldrum*'s acid (**5**; 1 mmol), and benzo[*a*]phenazin-5-ol (**3a**; 1 mmol), in the presence of 10 mol-% Et_3N, at ambient temperature, for 24 h.

The effect of various catalysts instead of Et_3N in the reaction has been investigated as well. Four usual basic catalysts have been considered. The results were compiled in *Table 2*. The data revealed that Et_3N was the best catalyst with respect to the reaction yield. It is worth mentioning that the reaction did not proceed in the absence of a catalyst.

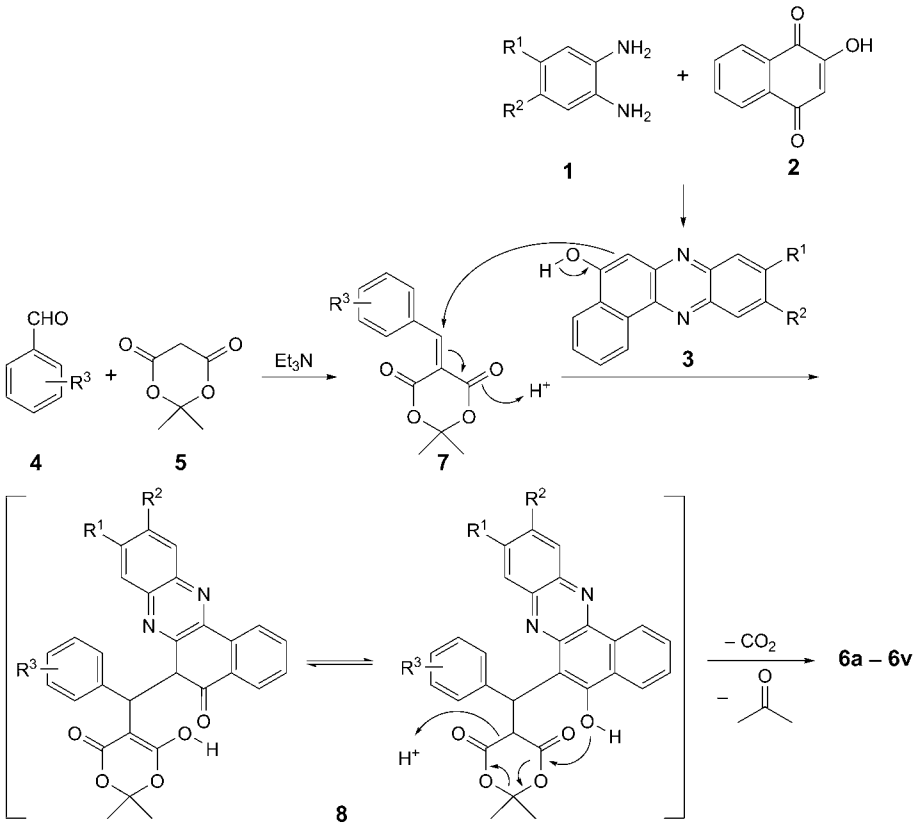
Table 2. *Effect of Catalysts*[a])

Entry	Catalyst	Amount [mol-%]	Yield [%]
1	–	–	–
2	Et_3N	15	86
3	Et_3N	10	86
4	Et_3N	5	74
5	Piperidine	10	73
6	Piperidine	5	70
7	Pyridine	10	70
8	Pyridine	5	67
9	DBU[b])	10	55
10	DBU	5	43

[a]) 4-Bromobenzaldehyde (**4a**; 1 mmol), *Meldrum*'s acid (**5**; 1 mmol), and benzo[*a*]phenazin-5-ol (**3a**; 1 mmol) in MeCN/EtOH 3 : 1 (8 ml), at ambient temperature, for 24 h. [b]) 1,8-Diazabicyclo[5.4.0]undec-7-ene

Although we have not studied the mechanistic aspects of the above mentioned reaction, a plausible pathway could be considered as shown in *Scheme 2*. The product of the first step could be obtained *via* two successive condensation reactions between **1** and **2**, in AcOH. The second step included the condensation between an aldehyde **4** and *Meldrum*'s acid (**5**) in the presence of a catalytic amount of Et_3N; then, the *Michael*-type addition of **3** to the intermediate **7** led to the intermediate **8**, and an intramolecular

Scheme 2. *Proposed Pathway*



cyclization along with simultaneous elimination of acetone and CO_2, gave the appropriate products **6a**–**6v**.

Conclusions. – In summary, we have developed a facile, straightforward, and efficient three-component approach for the synthesis of phenazine derivatives **6** from readily available starting materials. The procedure is very simple, and products could be separated from reaction media by simple filtration. The presented procedure displays good functional-group tolerance, and the benzo[*a*]phenazin-5-ols **3** or aldehydes **4** containing electron-donating and electron-withdrawing functional groups could be used in the reaction successfully. We hope that this approach may be of value in search of novel synthetic fragments with unique properties for medicinal chemistry.

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Experimental Part

General. All chemicals were obtained from *Fluka* or *Merck*, and were applied without further purification. M.p.: *Electrothermal-9100* apparatus. IR Spectra: *Bomem-MBFT-IR* spectrophotometer; in KBr; $\tilde{\nu}$ in cm^{-1}. ^1H- and ^{13}C-NMR spectra: *Bruker-DRX-300-Avance* spectrometer; in $(D_6)DMSO$; δ in ppm rel. to Me_4Si as internal standard, *J* in Hz. MS: *Shimadzu-GCMS-QP-1100EX* mass spectrometer; at 70 eV; in *m*/*z* (rel. %). Elemental analyses: *Elementaranalysensysteme GmbH VarioEL*, CHNS mode.

*Synthesis of Benzo[*a*]phenazin-5-ol* (**3a**) [29]. To a magnetically stirred soln. of *benzene-1,2-diamine* (**1a**; 0.11 g, 1 mmol) in AcOH (5 ml), *1,4-dihydro-2-hydroxynaphthalene-1,4-dione* (**2**; 0.17 g, 1 mmol) was added. The precipitated product was separated by filtration after 24 h. The product was washed with H_2O (10 ml) to remove any acid residue. The desired product was obtained as an orange powder. Yield: 0.22 g (88%). M.p. 294° (dec.). IR (KBr): 3425, 1633, 1592. ^1H-NMR (300 MHz): 7.17 (br. *s*, 1 arom. H); 7.80–8.31 (*m*, 7 arom. H); 9.25 (br. *s*, 1 arom. H); 11.53 (*s*, OH). ^{13}C-NMR (75 MHz): 98.2; 114.9; 125.7; 125.9; 127.1; 130.0; 130.4; 131.9; 132.1; 132.6; 132.9; 136.0; 136.4; 140.9; 145.2; 172.7. Anal. calc. for $C_{16}H_{10}N_2O$ (246.27): C 78.03, H 4.09, N 11.38; found: C 78.08, H 4.13, N 11.32.

*9-Methylbenzo[*a*]phenazin-5-ol* (**3b**). Yield: 0.23 g (91%). Orange powder. M.p. 273° (dec.). IR (KBr): 3421, 1638, 1589. ^1H-NMR (300 MHz): 2.60 (*s*, Me); 7.15 (*s*, 1 arom. H); 7.65–8.29 (*m*, 6 arom. H); 9.22 (br. *s*, 1 arom. H); 11.42 (br. *s*, OH). MS: 260 (100, M^+), 231 (30). Anal. calc. for $C_{17}H_{12}N_2O$ (260.09): C 78.44, H 4.65, N 10.76; found: C 78.39, H 4.67, N 10.71.

*9-Nitrobenzo[*a*]phenazin-5-ol* (**3c**) [30]. Yield: 0.22 g (76%). Orange powder. M.p. 282° (dec.). IR (KBr): 3426, 1631, 1583. ^1H-NMR (300 MHz): 7.04 (*s*, 2 arom. H); 7.86–8.32 (*m*, 4 arom. H); 8.81 (br. *s*, 1 arom. H); 9.08 (br. *s*, 1 arom. H); 11.80 (br. *s*, OH). MS: 291 (100, M^+), 245 (65), 216 (45). Anal. calc. for $C_{16}H_9N_3O_3$ (291.06): C 65.98, H 3.11, N 14.43; found: C 65.91, H 3.08, N 14.39.

*9,10-Dichlorobenzo[*a*]phenazin-5-ol* (**3d**). Yield: 0.26 g (83%). Orange powder. M.p. 297° (dec.). IR (KBr): 3431, 1627, 1580. ^1H-NMR (300 MHz): 7.09 (*s*, 1 arom. H); 7.90–8.47 (*m*, 5 arom. H); 9.12 (*d*, $J = 3$, 1 arom. H); 11.74 (br. *s*, OH). MS: 314 (100, M^+), 286 (60), 251 (25). Anal. calc. for $C_{16}H_8Cl_2N_2O$ (314.00): C 60.98, H 2.56, N 8.89; found: C 60.90, H 2.59, N 8.76.

*Synthesis of 1-(4-Bromophenyl)-1,2-dihydro-3*H*-benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6a**). Compound **3a** (0.25 g, 1 mmol) was added to a magnetically stirred mixture of *4-bromobenzaldehyde* (**4a**; 0.18 g, 1 mmol) and *Meldrum*'s acid (**5**; 0.14 g, 1 mmol) in MeCN/EtOH 3:1 (8 ml) in the presence of Et_3N (10 mol-%), and the mixture was stirred for 24 h. The precipitated product was separated by filtration and washed with H_2O (10 ml) and AcOEt (5 ml), and recrystallized from EtOH/H_2O 3:1 to give **6a** (0.39 g, 86%). Yellow powder. M.p. 335° (dec.). IR (KBr): 1786, 1487, 1412. ^1H-NMR (300 MHz): 3.20 (br. *d*, $J = 16$, 1 H of CH_2); 3.68 (*dd*, $^2J = 18$, $^3J = 9$, 1 H of CH_2); 5.53 (*d*, $J = 9$, CH); 7.26 (*d*, $^3J = 6$, 2 arom. H); 7.45 (*d*, $^3J = 6$, 2 arom. H); 7.95–8.39 (*m*, 7 arom. H); 9.36 (*d*, $J = 5$, 1 arom. H). ^{13}C-NMR (75 MHz): 35.2; 36.9; 115.4; 116.8; 117.6; 117.9; 118.1; 118.5; 119.8; 122.4; 126.2; 126.5; 127.5; 128.1; 129.0; 131.0; 131.4; 134.6; 134.9; 144.0; 149.3; 158.8; 177.3. MS: 456 (40, $M^+(^{81}Br)$), 428 (60), 411 (25), 271 (100), 167 (50). Anal. calc. for $C_{25}H_{15}BrN_2O_2$ (455.31): C 65.95, H 3.32, N 6.15; found: C 65.91, H 3.30, N 6.19.

*1-(4-Chlorophenyl)-1,2-dihydro-3*H*-benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6b**). Yield: 0.38 g (92%). Yellow powder. M.p. 320° (dec.). IR (KBr): 3436, 1783, 1630, 1488. ^1H-NMR (300 MHz): 3.20 (br. *d*, $J = 19$, 1 H of CH_2); 3.70 (*dd*, $J = 19$, $^3J = 6.5$, 1 H of CH_2); 5.53 (br. *d*, $J = 6.5$, CH); 7.26 (*d*, $J = 8$, 2 arom. H); 7.46 (*d*, $J = 8$, 2 arom. H); 7.95–8.37 (*m*, 7 arom. H); 9.36 (*d*, $J = 5$, 1 arom. H). ^{13}C-NMR (75 MHz): 36.0; 36.5; 116.2; 116.5; 117.4; 117.5; 118.0; 119.5; 119.8; 122.5; 126.2; 126.5; 128.0; 129.5; 131.0; 131.4; 134.5; 134.9; 136.7; 141.1; 149.2; 158.7; 177.3. MS: 410 (50, M^+), 345 (20), 271 (100), 167 (30). Anal. calc. for $C_{25}H_{15}ClN_2O_2$ (410.08): C 73.08, H 3.68, N 6.82; found: C 73.12, H 3.64, N 6.83.

*1,2-Dihydro-1-(4-methoxyphenyl)-3*H*-benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6c**). Yield: 0.30 g (75%). Yellow powder. M.p. 317° (dec.). IR (KBr): 3435, 1783, 1631, 1600. ^1H-NMR (300 MHz): 3.20 (br. *d*, $J = 15$, 1 H of CH_2); 3.63 (br. *s*, MeO, 1 H of CH_2); 5.50 (*d*, $J = 6$, CH); 6.82 (*d*, $J = 6.5$, 2 arom. H); 7.21 (*d*, $J = 6.5$, 2 arom. H); 7.96–8.39 (*m*, 7 arom. H); 9.37 (*d*, $J = 6$, 1 arom. H). ^{13}C-NMR (75 MHz): 36.0; 36.5; 116.2; 116.5; 117.4; 117.5; 118.0; 119.5; 119.8; 122.5; 126.2; 126.5; 128.0; 129.5; 131.0; 131.4; 134.5; 134.9; 136.7; 141.3; 149.2; 158.7; 177.3. MS: 406 (50, M^+), 378 (100), 271 (75), 182 (30). Anal. calc. for $C_{26}H_{18}N_2O_3$ (406.13): C 76.83, H 4.46, N 6.89; found: C 76.86, H 4.41, N 6.92.

*1-(3-Bromophenyl)-1,2-dihydro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6d**). Yield: 0.36 g (80%). Yellow powder. M.p. 337° (dec.). IR (KBr): 3437, 1783, 1401. ^{1}H-NMR (300 MHz): 3.23 (br. *d*, *J* = 15, 1 H of CH_2); 3.68 (*dd*, ^2J = 18, ^3J = 9, 1 H of CH_2); 5.55 (*d*, *J* = 6, CH); 7.23–8.37 (*m*, 11 arom. H); 9.37 (*d*, *J* = 9, 1 arom. H). ^{13}C-NMR (75 MHz): 35.2; 36.4; 116.6; 116.7; 116.9; 117.2; 117.5; 117.9; 118.1; 118.5; 119.6; 121.8; 126.2; 126.5; 128.9; 130.1; 131.1; 131.4; 132.4; 134.6; 134.9; 143.2; 149.4; 158.8; 177.2. MS: 454 (25, M^+), 428 (50), 271 (100), 167 (30). Anal. calc. for $C_{25}H_{15}BrN_2O_2$ (454.03): C 65.95, H 3.32, N 6.15; found: C 65.92, H 3.36, N 6.17.

*1-(2-Bromophenyl)-1,2-dihydro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6e**). Yield: 0.38 g (83%). Yellow powder. M.p. 302° (dec.). IR (KBr): 3437, 1779, 1468. ^{1}H-NMR (300 MHz): 3.02 (br. *d*, *J* = 16, 1 H of CH_2); 3.75 (*dd*, ^2J = 18, ^3J = 9, 1 H of CH_2); 5.81 (*d*, *J* = 9, CH); 6.88 (br. *s*, 1 arom. H); 7.11 (br. *s*, 2 arom. H); 7.74–8.30 (*m*, 8 arom. H); 9.35 (*d*, *J* = 4, 1 arom. H). ^{13}C-NMR (75 MHz): 35.4; 36.9; 116.0; 116.5; 116.9; 117.4; 117.9; 118.1; 118.7; 119.2; 121.2; 126.4; 126.9; 128.9; 130.6; 131.7; 131.8; 132.1; 133.1; 134.0; 143.4; 149.7; 158.7; 176.5. MS: 454 (5, M^+), 375 (80), 333 (100), 271 (45). Anal. calc. for $C_{25}H_{15}BrN_2O_2$ (454.03): C 65.95, H 3.32, N 6.15; found: C 65.97, H 3.33, N 6.19.

*1,2-Dihydro-1-(4-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6f**). Yield: 0.36 g (86%). Yellow powder. M.p. 314° (dec.). IR (KBr): 3435, 1774, 1462. ^{1}H-NMR (300 MHz): 3.20 (br. *d*, *J* = 15, 1 H of CH_2); 3.70 (*d*, ^2J = 15, ^3J = 7.5, 1 H of CH_2); 5.58 (*d*, *J* = 6, CH); 7.33 (*s*, 4 arom. H); 7.98 (*d*, *J* = 6, 4 arom. H); 8.17 (*s*, 1 arom. H); 8.34 (*d*, *J* = 6, 2 arom. H); 9.36 (*d*, *J* = 5, 1 arom. H). ^{13}C-NMR (75 MHz): 35.4; 36.8; 112.9; 114.1; 119.7; 120.3; 122.1; 122.3; 123.2; 123.7; 124.1; 124.2; 126.2; 126.5; 130.2; 131.1; 131.1; 134.5; 134.8; 145.6; 149.4; 158.8; 177.4. MS: 421 (5, M^+), 410 (60), 382 (100), 365 (30). Anal. calc. for $C_{25}H_{15}N_3O_4$ (421.11): C 71.25, H 3.59, N 9.97; found: C 71.20, H 3.52, N 9.91.

*1-(4-Fluorophenyl)-1,2-dihydro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6g**). Yield: 0.36 g (92%). Yellow powder. M.p. 305° (dec.). IR (KBr): 3435, 1770, 1465. ^{1}H-NMR (300 MHz): 3.20 (br. *d*, *J* = 15, 1 H of CH_2); 3.70 (*dd*, ^2J = 15, ^3J = 6, 1 H of CH_2); 5.56 (br. *d*, *J* = 6, CH); 7.27 (*d*, *J* = 6, 2 arom. H); 7.46 (*d*, *J* = 6, 2 arom. H); 7.96–8.38 (*m*, 7 arom. H); 9.37 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 36.2; 36.7; 116.0; 116.1; 116.4; 117.6; 117.9; 121.1; 122.8; 123.4; 124.2; 126.5; 127.5; 128.3; 129.6; 131.9; 132.2; 134.5; 134.7; 144.0; 149.3; 159.8; 177.9. MS: 394 (10, M^+), 320 (10), 292 (15), 91 (100). Anal. calc. for $C_{25}H_{15}FN_2O_2$ (394.11): C 76.13, H 3.83, N 7.10; found: C 76.18, H 3.87, N 7.14.

*1-(4-Bromophenyl)-1,2-dihydro-11-methyl-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6h**). Yield: 0.36 g (77%). Yellow powder. M.p. 294° (dec.). IR (KBr): 3440, 1779, 1634, 1485. ^{1}H-NMR (300 MHz): 2.64 (*s*, Me); 3.8 (br. *d*, *J* = 12, 1 H of CH_2); 3.66 (*dd*, ^2J = 12, ^3J = 6, 1 H of CH_2); 5.55 (*d*, *J* = 6, CH); 7.26 (*d*, *J* = 6, 2 arom. H); 7.45 (*d*, *J* = 6, 2 arom. H); 7.77–8.29 (*m*, 5 arom. H); 9.33 (*d*, *J* = 3, 1 arom. H). ^{13}C-NMR (75 MHz): 23.8; 33.3; 35.8; 116.0; 116.6; 117.4; 118.9; 119.8; 121.6; 126.2; 126.5; 128.1; 129.2; 129.4; 130.0; 131.3; 131.4; 134.4; 135.2; 141.1; 149.8; 156.9; 177.0. MS: 468 (20, M^+), 440 (50), 285 (100), 174 (30). Anal. calc. for $C_{26}H_{17}BrN_2O_2$ (468.05): C 66.54, H 3.65, N 5.97; found: C 66.59, H 3.60, N 5.93.

*1,2-Dihydro-11-methyl-1-(4-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6i**). Yield: 0.40 g (92%). Yellow powder. M.p. 314° (dec.). IR (KBr): 3443, 1782, 1640, 1516. ^{1}H-NMR (300 MHz): 2.57 (*s*, Me); 3.26 (br. *d*, *J* = 18, 1 H of CH_2); 3.72 (*dd*, ^2J = 18, ^3J = 8, 1 H of CH_2); 5.65 (*d*, *J* = 8, CH); 7.57–8.31 (*m*, 10 arom. H); 9.29 (*d*, *J* = 4, 1 arom. H). ^{13}C-NMR (75 MHz): 22.2; 36.6; 37.7; 112.1; 112.3; 115.6; 122.4; 122.5; 123.4; 124.7; 125.8; 126.2; 126.5; 127.2; 128.9; 130.8; 131.7; 134.8; 135.3; 144.6; 155.0; 161.2; 168.9; 179.5. MS: 435 (60, M^+), 407 (90), 285 (100), 180 (20). Anal. calc. for $C_{26}H_{17}N_3O_4$ (435.12): C 71.72, H 3.94, N 9.65; found: C 71.70, H 3.97, N 9.60.

*1-(3-Bromophenyl)-1,2-dihydro-11-methyl-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6j**). Yield: 0.39 g (85%). Yellow powder. M.p. 327° (dec.). IR (KBr): 3444, 1781, 1396. ^{1}H-NMR (300 MHz): 2.58 (*s*, Me); 3.17 (br. *d*, *J* = 15, 1 H of CH_2); 3.60 (*dd*, ^2J = 15, ^3J = 8, 1 H of CH_2); 5.52 (*d*, *J* = 8, CH); 7.22–8.22 (*m*, 10 arom. H); 9.28 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 21.6; 36.2; 36.7; 112.1; 112.4; 116.6; 117.9; 119.2; 119.3; 120.3; 120.8; 122.9; 123.0; 126.2; 126.4; 130.5; 131.9; 132.2; 134.4; 134.5; 135.9; 146.4; 147.9; 149.6; 158.1; 177.0. MS: 468 (40, M^+), 440 (50), 285 (100), 174 (20). Anal. calc. for $C_{26}H_{17}BrN_2O_2$ (468.05): C 66.54, H 3.65, N 5.97; found: C 66.58, H 3.62, N 5.91.

*1,2-Dihydro-11-methyl-1-(3-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6k**). Yield: 0.38 g (89%). Yellow powder. M.p. 298° (dec.). IR (KBr): 3430, 1778, 1465. ^{1}H-NMR (300 MHz): 2.72 (*s*, Me); 3.25 (br. *d*, *J* = 15, 1 H of CH_2); 3.68 (*dd*, ^2J = 15, ^3J = 9, 1 H of CH_2); 5.60 (br. *d*, *J* = 9, CH);

7.22 – 8.36 (*m*, 10 arom. H); 9.37 (*d*, *J* = 3, 1 arom. H). ^{13}C-NMR (75 MHz): 22.6; 36.1; 36.8; 114.3; 117.2; 117.6; 119.1; 122.3; 126.4; 126.6; 129.4; 131.3; 131.5; 134.2; 135.0; 137.2; 137.4; 138.3; 139.4; 140.4; 146.5; 146.9; 149.2; 155.0; 158.7; 177.3. MS: 435 (15, M^+), 359 (20), 282 (100), 174 (30). Anal. calc. for $C_{26}H_{17}N_3O_4$ (435.12): C 71.72, H 3.94, N 9.65; found: C 71.68, H 3.98, N 9.60.

*1,2-Dihydro-11-methyl-1-(2-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6l**). Yield: 0.39 g (80%). Yellow powder. M.p. 311° (dec.). IR (KBr): 3430, 1778, 1466. ^{1}H-NMR (300 MHz): 2.60 (*s*, Me); 3.10 (br. *d*, *J* = 15, 1 H of CH_2); 3.95 (*dd*, ^2J = 15, ^3J = 6, 1 H of CH_2); 5.84 (*d*, *J* = 6, CH); 7.22 – 8.38 (*m*, 10 arom. H); 9.29 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 26.7; 35.4; 37.1; 112.2; 112.4; 115.3; 117.2; 119.5; 120.2; 122.7; 122.9; 125.6; 126.8; 128.1; 128.5; 131.4; 132.7; 139.6; 139.7; 140.0; 140.1; 144.2; 155.0; 161.1; 168.4; 179.5. MS: 435 (15, M^+), 323 (100), 241 (15), 75 (10). Anal. calc. for $C_{26}H_{17}N_3O_4$ (435.12): C 71.72, H 3.94, N 9.65; found: C 71.67, H 3.89, N 9.61.

*1-(4-Fluorophenyl)-1,2-dihydro-11-methyl-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6m**). Yield: 0.34 g (84%). Yellow powder. M.p. 317° (dec.). IR (KBr): 3432, 1770, 1469. ^{1}H-NMR (300 MHz): 2.64 (*s*, Me); 3.20 (br. *d*, *J* = 15, 1 H of CH_2); 3.70 (*dd*, ^2J = 15, ^3J = 6, 1 H of CH_2); 5.54 (br. *d*, *J* = 9, CH); 7.26 (*d*, *J* = 6, 2 arom. H); 7.46 (*d*, *J* = 6, 1 arom. H); 7.81 – 8.31 (*m*, 6 arom. H); 9.33 (*d*, *J* = 3, 1 arom. H). ^{13}C-NMR (75 MHz): 26.1; 33.7; 35.2; 113.1; 113.7; 114.6; 114.8; 115.8; 116.0; 118.2; 120.9; 124.8; 126.1; 128.8; 130.2; 130.4; 131.1; 132.0; 133.3; 134.2; 144.9; 156.7; 160.1; 181.6. MS: 408 (5, M^+), 382 (30), 363 (60), 323 (70), 138 (100). Anal. calc. for $C_{26}H_{17}FN_2O_2$ (408.13): C 76.46, H 4.20, N 6.86; found: C 76.41, H 4.17, N 6.81.

*1-(4-Bromophenyl)-1,2-dihydro-11-nitro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6n**). Yield: 0.37 g (75%). Yellow powder. M.p. 294° (dec.). IR (KBr): 3441, 1779, 1689, 1628. ^{1}H-NMR (300 MHz): 3.20 (br. *d*, *J* = 15, 1 H of CH_2); 3.69 (*dd*, ^2J = 15, ^3J = 6, 1 H of CH_2); 5.51 (*d*, *J* = 9, CH); 7.30 (*d*, *J* = 9, 2 arom. H); 7.47 (*d*, *J* = 6, 2 arom. H); 8.01 – 8.64 (*m*, 6 arom. H); 9.29 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 34.6; 35.0; 112.4; 112.6; 113.0; 114.4; 119.3; 121.6; 125.2; 126.5; 128.2; 129.2; 129.6; 130.9; 131.0; 132.3; 132.8; 133.5; 135.6; 141.9; 148.1; 158.8; 178.3. MS: 500 (20, M^+), 470 (40), 315 (100), 158 (20). Anal. calc. for $C_{25}H_{14}BrN_3O_4$ (499.02): C 60.02, H 2.82, N 8.40; found: C 60.04, H 2.84, N 8.37.

*1-(2,4-Dimethoxyphenyl)-1,2-dihydro-11-nitro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6o**). Yield: 0.33 g (68%). Yellow powder. M.p. 332° (dec.). IR (KBr): 3434, 1777, 1603, 1512. ^{1}H-NMR (300 MHz): 3.00 (br. *d*, *J* = 18, 1 H of CH_2); 3.48 (br. *s*, MeO, 1 H of CH_2); 3.83 (*s*, MeO); 5.55 (*d*, *J* = 6, CH); 6.34 – 9.15 (*m*, 9 arom. H); 9.35 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 34.9; 36.8; 55.4; 57.8; 112.7; 114.9; 115.1; 115.2; 116.4; 119.5; 122.6; 124.2; 129.4; 130.3; 130.9; 132.5; 132.6; 134.5; 136.1; 136.4; 137.2; 137.5; 142.8; 149.4; 155.9; 158.8; 179.4. MS: 481 (100, M^+), 453 (90), 436 (70), 220 (60). Anal. calc. for $C_{27}H_{19}N_3O_6$ (481.13): C 67.36, H 3.98, N 8.73; found: C 67.32, H 3.93, N 8.75.

*1,2-Dihydro-11-nitro-1-(2-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6p**). Yield: 0.37 g (80%). Yellow powder. M.p. 308° (dec.). IR (KBr): 3430, 1783, 1642, 1525. ^{1}H-NMR (300 MHz): 3.16 (br. *d*, *J* = 18, 1 H of CH_2); 3.93 (*dd*, ^2J = 15, ^3J = 9, 1 H of CH_2); 5.81 (*d*, *J* = 8.4, CH); 6.25 – 8.65 (*m*, 10 arom. H); 9.25 (*d*, *J* = 9, 1 arom. H). ^{13}C-NMR (75 MHz): 34.9; 36.7; 113.2; 113.3; 114.1; 115.4; 116.3; 118.8; 119.9; 120.4; 122.9; 125.4; 126.6; 126.9; 130.7; 131.1; 131.2; 133.3; 133.6; 135.5; 146.9; 148.6; 149.9; 158.2; 174.7. MS: 466 (5, M^+), 428 (100), 400 (90), 341 (20). Anal. calc. for $C_{25}H_{14}N_4O_6$ (466.09): C 64.38, H 3.03, N 12.01; found: C 64.31, H 3.00, N 12.06.

*1,2-Dihydro-11-nitro-1-(4-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6q**). Yield: 0.37 g (81%). Yellow powder. M.p. 298° (dec.). IR (KBr): 3435, 1774, 1469. ^{1}H-NMR (300 MHz): 3.23 (br. *d*, *J* = 18, 1 H of CH_2); 3.73 (*dd*, ^2J = 17, ^3J = 9, 1 H of CH_2); 5.54 (*d*, *J* = 6, CH); 7.32 (*d*, *J* = 9, 2 arom. H); 7.48 (*d*, *J* = 9, 1 arom. H); 8.02 – 8.96 (*m*, 6 arom. H); 9.34 (*d*, *J* = 6, 1 arom. H). ^{13}C-NMR (75 MHz): 34.9; 36.5; 112.6; 112.9; 113.1; 113.2; 114.5; 115.4; 119.6; 120.5; 121.4; 126.4; 126.5; 132.0; 132.5; 132.6; 132.7; 134.7; 134.8; 143.2; 149.5; 155.9; 177.8. MS: 466 (10, M^+), 403 (20), 360 (40), 334 (100). Anal. calc. for $C_{25}H_{14}N_4O_6$ (466.09): C 64.38, H 3.03, N 12.01; found: C 64.32, H 3.09, N 12.06.

*1-(4-Bromophenyl)-11,12-dichloro-1,2-dihydro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6r**). Yield: 0.36 g (68%). Yellow powder. M.p. 291° (dec.). IR (KBr): 3430, 1783, 1617. ^{1}H-NMR (300 MHz): 3.20 (br. *d*, *J* = 15, 1 H of CH_2); 3.67 (*dd*, ^2J = 15, ^3J = 6, 1 H of CH_2); 5.44 (*d*, *J* = 6, CH); 7.28 (*d*, *J* = 6, 2 arom. H); 7.45 (*d*, *J* = 6, 2 arom. H); 8.03 – 8.71 (*m*, 5 arom. H); 9.30 (*d*, *J* = 5, 1 arom. H). ^{13}C-NMR (75 MHz): 35.1; 36.7; 113.2; 114.1; 119.7; 121.3; 122.1; 122.3; 123.7; 123.8; 124.1; 125.2; 126.2;

126.5; 130.2; 131.1; 131.6; 133.5; 134.8; 145.3; 149.4; 158.9; 178.3. MS: 524 (30, M^+), 496 (70), 339 (100), 201 (20). Anal. calc. for $C_{25}H_{13}BrCl_2N_2O_2$ (521.95): C 57.28, H 2.50, N 5.34; found: C 57.21, H 2.52, N 5.36.

*11,12-Dichloro-1,2-dihydro-1-(4-methylphenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6s**). Yield: 0.35 g (76%). Yellow powder. M.p. 296° (dec.). IR (KBr): 3432, 1783, 1610, 1521. ^{1}H-NMR (300 MHz): 2.10 (*s*, Me); 3.10 (br. *d*, $J = 15$, 1 H of CH_2); 3.63 (*dd*, $^2J = 15$, $^3J = 6$, 1 H of CH_2); 5.45 (*d*, $J = 6$, CH); 7.07 (*d*, $J = 6$, 2 arom. H); 7.15 (*d*, $J = 6$, 2 arom. H); 8.03 – 8.68 (*m*, 5 arom. H); 9.28 (*d*, $J = 5$, 1 arom. H). ^{13}C-NMR (75 MHz): 23.2; 34.9; 36.8; 112.1; 112.4; 113.5; 113.9; 114.5; 115.1; 119.3; 120.6; 122.1; 126.2; 126.0; 130.2; 131.4; 132.7; 134.5; 134.9; 146.2; 149.4; 158.8; 160.8; 177.5. MS: 459 (30, M^+), 496 (70), 339 (100), 201 (20). Anal. calc. for $C_{26}H_{16}Cl_2N_2O_2$ (458.06): C 67.99, H 3.51, N 6.10; found: C 67.92, H 3.53, N 6.16.

*1-(3-Bromophenyl)-11,12-dichloro-1,2-dihydro-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6t**). Yield: 0.43 g (82%). Yellow powder. M.p. 314° (dec.). IR (KBr): 3437, 1773, 1639. ^{1}H-NMR (300 MHz): 3.29 (br. *d*, $J = 18$, 1 H of CH_2); 4.31 (*dd*, $^2J = 18$, $^3J = 9$, 1 H of CH_2); 5.51 (*d*, $J = 9$, CH); 7.19 – 8.67 (*m*, 9 arom. H); 9.29 (*d*, $J = 6$, 1 arom. H). ^{13}C-NMR (75 MHz): 33.7; 35.2; 112.1; 113.7; 113.8; 114.4; 114.8; 115.2; 117.0; 117.9; 118.1; 120.8; 124.1; 126.8; 128.0; 130.2; 130.8; 131.2; 132.4; 133.1; 134.1; 148.7; 156.6; 162.8; 181.7. MS: 524 (30, M^+), 496 (70), 339 (100), 201 (20). Anal. calc. for $C_{25}H_{13}BrCl_2N_2O_2$ (521.95): C 57.28, H 2.50, N 5.34; found: C 57.32, H 2.53, N 5.37.

*11,12-Dichloro-1,2-dihydro-1-phenyl-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6u**). Yield: 0.41 g (92%). Yellow powder. M.p. 325° (dec.). IR (KBr): 3431, 1785, 1634, 1444. ^{1}H-NMR (300 MHz): 3.21 (br. *d*, $J = 18$, 1 H of CH_2); 3.70 (*dd*, $^2J = 18$, $^3J = 8.0$, 1 H of CH_2); 5.46 (br. *d*, $J = 8.0$, CH); 7.20 – 8.44 (*m*, 10 arom. H); 9.10 (*d*, $J = 5$, 1 arom. H). ^{13}C-NMR (75 MHz): 34.5; 36.6; 112.1; 112.8; 113.7; 113.9; 115.4; 119.7; 121.5; 122.7; 125.5; 126.4; 127.3; 130.3; 130.6; 131.2; 131.4; 134.2; 135.3; 146.3; 148.6; 159.4; 177.4. MS: 444 (50, M^+), 416 (100), 339 (90), 201 (10). Anal. calc. for $C_{25}H_{14}Cl_2N_2O_2$ (444.04): C 67.43, H 3.17, N 6.29; found: C 67.40, H 3.11, N 6.34.

*11,12-Dichloro-1,2-dihydro-1-(4-nitrophenyl)-3*H-*benzo[*a*]pyrano[2,3-*c*]phenazin-3-one* (**6v**). Yield: 0.41 g (84%). Yellow powder. M.p. 298° (dec.). IR (KBr): 3438, 1771, 1469. ^{1}H-NMR (300 MHz): 3.21 (br. *d*, $J = 15$, 1 H of CH_2); 3.70 (*dd*, $^2J = 15$, $^3J = 6$, 1 H of CH_2); 5.47 (br. *d*, $J = 6$, CH); 7.29 (*d*, $J = 9$, 2 arom. H); 7.48 (*d*, $J = 9$, 2 arom. H); 8.02 – 8.63 (*m*, 5 arom. H); 9.25 (*d*, $J = 9$, 1 arom. H). ^{13}C-NMR (75 MHz,): 34.4; 36.6; 116.5; 116.6; 116.9; 117.3; 117.6; 122.2; 123.0; 124.0; 124.4; 126.6; 127.9; 128.1; 129.8; 131.4; 132.2; 135.5; 135.8; 145.0; 149.3; 159.7; 177.5. MS: 489 (10, M^+), 4434 (10), 323 (100), 246 (10). Anal. calc. for $C_{25}H_{13}C_{l2}N_3O_4$ (489.03): C 61.24, H 2.67, N 8.57; found: C 61.29, H 2.62, N 8.51.

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