HL
http://heteroletters.org

ISSN: 2231 – 3087(print)
ISSN: 2230 – 9632 (Online)
Coden HLEEAI
Vol. 4: (3), 2014, 341-348

FOUR-COMPONENT DOMINO SYNTHESES OF 1*H*-PYRAZOLO[1,2-*B*]PHTHALAZINE-5,10-DIONES & 2H-INDAZOLO[2,1-B]PHTHALAZINE-1,6,11(13H)-TRIONES IN WATER

Y. Dathu Reddy*, B. Suryanarayana, Ch. Venkata Ramana Reddy & P. K. Dubey

Department of Chemistry,
Jawaharlal Nehru Technological University Hyderabad College of Engineering,
Kukatpally, Hyderabad (A.P), India - 500 085.
E-mail ID: dathureddyjntuh@gmail.com

Abstract
Four component domino syntheses for the preparation of 1*H*-Pyrazolo[1,2-*b*]phthalazine-5,10-diones **(5)** & 2H-indazolo[2,1-b]phthalazine-1,6,11(13H)-triones **(7)** have been described from phthalimide **(1)** , hydrazine hydrate **(2)**, benzaldehydes **(3)** and malononitrile **(4a)**/ethyl cyanoacetate **(4b)** /dimedone **(6)** in refluxing water for 1.5-2 h in the presence of $InCl_3$ as a catalyst. This reactions have an easy workup, provides excellent yields, and uses water as the solvent which is considered to be relatively environmentally benign.

Keywords: Water, phthalimide, green syntheses.

Introduction:

Phthalazines are important heterocycles that are known to possess multiple biological activities such as antimicrobial[i], anticonvulsant[ii], antifungal[iii], anticancer[iv] and anti-inflammatory[v]. Therefore, a number of methods have been reported for the syntheses of phthalazine derivatives[vi-vii]. Recently, syntheses of 1-aryl-1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-diones was reported by one-pot, three component condensation of phthalhydrazide, malononitrile/ethyl cyanoacetate and benzaldehydes using one of the following conditions:- a) In the presence of a catalytic amount of p-toluenesulfonic acid (p-TSA) in ionic liquid, 1-butyl-3-methylimidazolium bromide ([bmim]Br), as solvent at 100 °C[viii] b) Using triethylamine (0.02 g, 20% mol) as catalyst in EtOH (5 ml) at 50 °C for 60 min under ultrasonication with a frequency of 50 kHz and an output power of 350W[ix]; c) using 1-butyl-3-methylimidazolium hydroxide ([Bmim]OH) under irradiation in a single-mode microwave oven at 100W power and 45°C[x]. The syntheses of 1-aryl-1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-diones were also reported by one-pot, four component syntheses of phthalimide, hydrazine, malononitrile/ethyl cyanoacetate and benzaldehydes, using basic ionic liquids such as1,8-diazabicyclo[5.4.0]-undec-7-en-8-ium acetate[xi], pyrrolidinium acetate[xi] and triethylamine[xii] as catalyst under ultrasound-sonication[xii]. The latter syntheses (i.e. four component reaction) are very similar to the previous syntheses (i.e.

three component reaction) except for the fact that phthalhydrazide has been prepared from phthalimide and hydrazine hydrate in situ in this reaction.

Keeping these results in mind and in continuation of earlier work on phthalimide[xiii], we now wish to report our intensive and extensive study of the four component domino reaction for syntheses of title compounds in water.

Results and Discussion:

As illustrated in **scheme 1**, the reaction of phthalimide **(1)** with hydrazine hydrate **(2)** in refluxing water for 15 min led to the in-situ formation of phthalhydrazide as intermediate. Then, to this reaction mixture was added benzaldehydes **(3a)** followed by malononitrile **(4a**) and the whole mixture again refluxed in the presence of $InCl_3$ as a catalyst in water for 1.5 h. Processing the reaction mixture led to the isolation of 1*H*-Pyrazolo[1,2-*b*]phthalazine-5,10-dione **(5a) (Table 1, entry 1)** as the final product. Then, this reaction was examined by carrying out the multi component reaction with **1, 2, 3a** and **4a** in the presence of different solvents (Water, Glycerol, PEG-600, ethylene glycol, DMF& DMSO) at 100 ^{o}C **(Table 1)**. However, multi component reaction of **1, 2, 3a & 4a** in water at 100 ^{o}C for 1.5 h was found to be the best method giving **5a** in quality & yield (~ 85%) (**Table 1, entry 1)**. Therefore, water was chosen as the solvent for the further study at 100 ^{o}C.

Scheme 1:

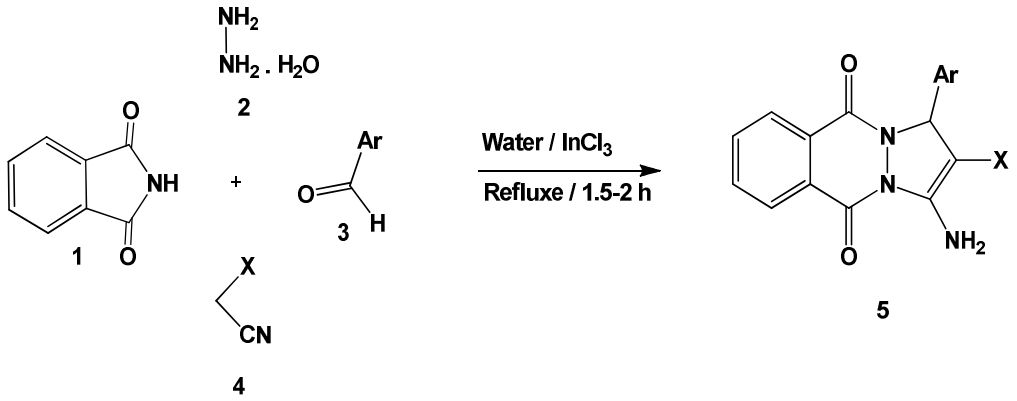


Table 1

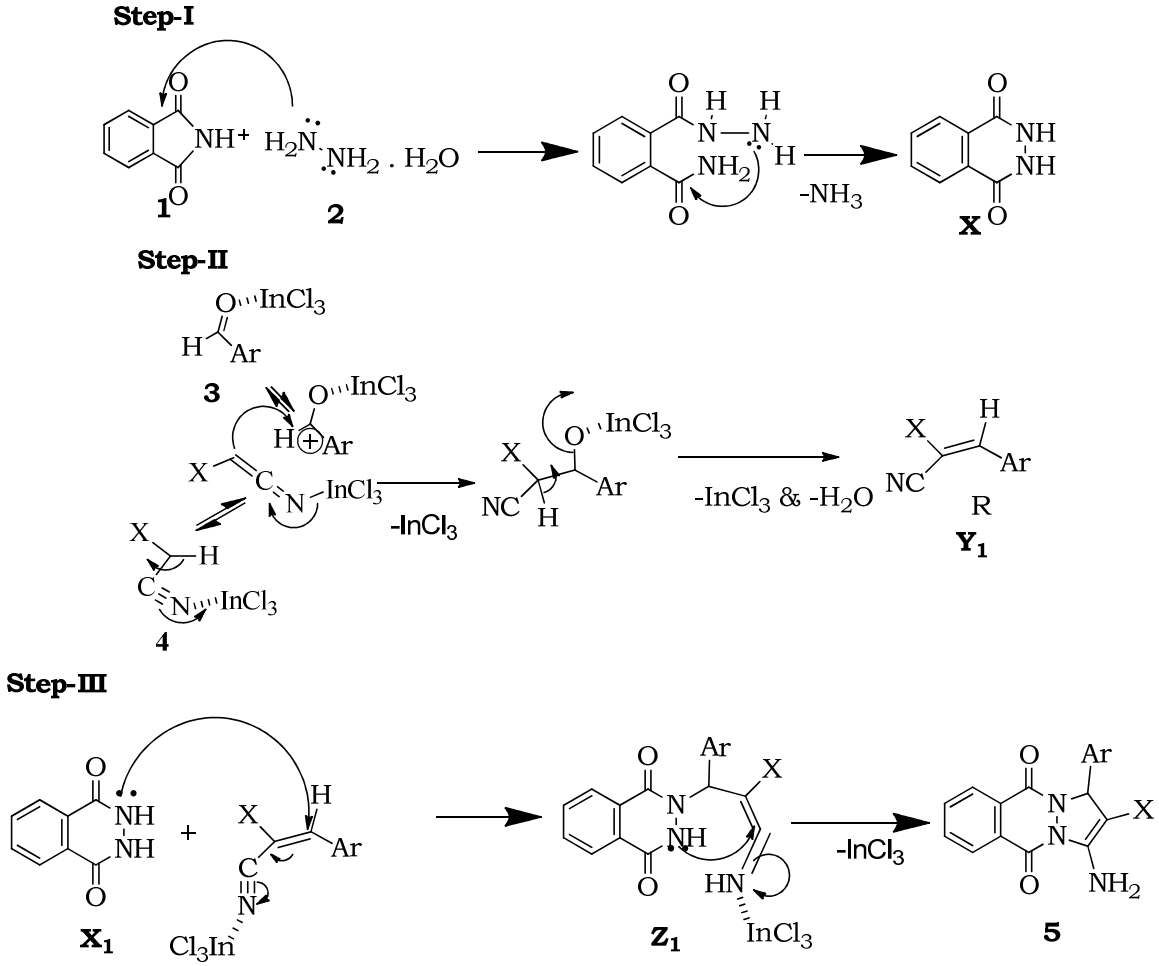
Effect of **Solvent** on reaction of **1**, **2, 3a & 4a** at RT yielding **5a.**

Entry	**Solvent**	**Temperature ^{o}C**	**Time (h)**	**5a (%)**
1	**Water**	**100**	**1.5**	**85**
2	Glycerol	100	2	70
3	PEG-600	100	2	75
4	Ethylene glycol	100	2	70
5	DMF	100	2	75
6	DMSO	100	2	65

The generality of this four-component reaction was studied under optimized conditions by varying the structures of aldehydes and active methylene compounds to form **5a-5h**. The results are summarized in **Table 2**. Generally, the reactions that employed aromatic aldehydes bearing electron-withdrawing or electron-donating functional groups at different positions produced the corresponding products **5** in good to excellent yields. The structures of the products were established from their spectral properties (^{1}H- NMR, ^{13}C-NMR) and also by comparison with available literature data.

A schematic mechanism for the synthesis of titled compounds **5** can be postulated as shown in **Scheme 2**. This mechanism contains three steps. In the first step, formation of phthalhydrazide **(X)** by nucleophilic addition of hydrazine hydrate **(2)** to phthalimide (**1**). The second step involves forming heterodiene **Y** by standard Knoevenagel condensation of benzaldehydes (**3)** and malononitrile/ethyl cyanoacetate (**4**). Then, in the third step, Michael-type addition of the phthalhydrazide **X** to heterodiene **Y** takes place forming the intermediary iminomethylene derivative **z** which undergoes cyclisation affording **5 (Scheme 2)**.

Plausible mechanism for 5 from 1, 2, 3 & 4: Scheme 2.



Keeping the above results in our mind, 2H-indazolo[2,1-b]phthalazine-1,6,11(13H)-triones **7a-7f** have been synthesised by one-pot, four component reaction from phthalimide **1**, hydrazine hydrate **2**, benzaldehydes **3a-3f** and dimedone **6** in water at 100 ^{o}C for 1.5 h in the presence of $InCl_3$. The yields obtained were good to excellent without formation of any side-products and all

reactions proceed rapidly in short times. The structures of the products were established from their spectral properties (^{1}H-NMR, ^{13}C-NMR) and also by comparison with available literature data **(Scheme 3).**

Scheme 3:

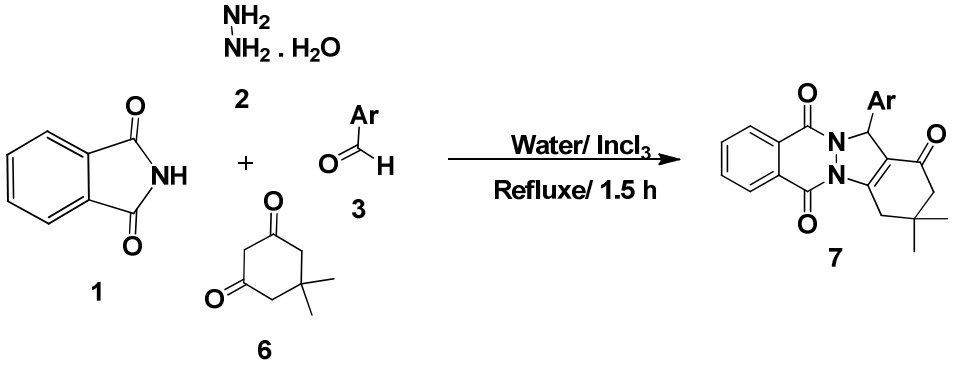


Table 2
Characterization data, reaction time and yields of **5** obtained from **1, 2, 3 & 4** via one-pot, four component syntheses.

Entry	Starting Materials				Product	Yield≠	M.P (Lit M.P)
1	1	2	3a (Ar= -ph)	4a (X= CN)	**5a**	85	275-276 (276-278)[xiv]
2	1	2	3b (Ar = 2-Cl-ph)	4a (X= CN)	**5b**	82	259-260 (259-261)[xiv]
3	1	2	3c (Ar = 4-Br-ph)	4a (X= CN)	**5c**	82	263-265 (265-267)[xv]
4	1	2	3d (Ar = 2-NO_2-ph)	4a (X= CN)	**5d**	84	229-230 (228-230)[xvi]
5	1	2	3a (Ar= -ph)	4b (X=COOEt)	**5e**	82	230-231 (232-234)[xvi]
6	1	2	3b (Ar = 2-Cl-ph)	4b (X=COOEt)	**5f**	82	265-267 (266-267)[xv]
7	1	2	3c (Ar = 4-Br-ph)	4b (X=COOEt)	**5g**	84	207-208 (205-206)[xv]
8	1	2	3d (Ar = 2-NO_2-ph)	4b (X=COOEt)	**5h**	84	232-233 (230-232)[xvi]

≠ Refers to yields of crude products only.

Table 3
Characterization data, reaction time and yields of **7** obtained from **1, 2, 3 & 6** via one-pot, four component syntheses.

Entry	Starting Materials				Product	Yield≠	M.P (Lit M.P)
1	1	2	3a (Ar= -ph)	6	**7a**	83	203-205 (204-206)[xvii]
2	1	2	3b (Ar = 2-Cl-ph)	6	**7b**	82	268-270 (266-269)[xvii]
3	1	2	3c (Ar = 4-Br-ph)	6	**7c**	81	262-264 (262-263)[xviii]
4	1	2	3d (Ar = 2-NO_2-ph)	6	**7d**	81	239-240 (238-240)[xviii]
5	1	2	3e (Ar= 3-NO_2-ph)	6	**7e**	81	267-269 (269-271)[xvii]
6	1	2	3f (Ar = 4-Cl-ph)	6	**7f**	82	258-259 (258-260)[xvii]

≠ Refers to yields of crude products only.

Conclusion

In summary, we have developed title compounds by one-pot, four-component synthesis in practical and green synthetic method with good yields. This method contain short reaction time, mild conditions with simple work-up procedure and environmentally benign process.

Experimental section

Melting points are uncorrected and were determined in open capillary tubes in sulphuric acid bath. TLC was run on silica gel – G and visualization was done using iodine or UV light. IR spectra were recorded using Perkin – Elmer 1000 instrument in KBr pellets. ^{1}H NMR spectra were recorded in DMSO – d_6 using TMS as internal standard at 400 MHz operating frequency. Mass spectra were recorded on Agilent-LCMS instrument.

General procedure for preparation of 5/7 from 1, 2, 3 & 4/6:

Phthalimide **(1)** (10 mmol) and hydrazine hydrate **(1)** (10 mmol) was refluxed in water for 10 min to form phthalhydrazide as intermediate. Then, to this reaction mixture added dimedone **(3)** (10 mmol) and malononitrile/ethyl cyanoacetate / dimedone **(4/6)** (10 mmol) in succession, one after another in the presence of $InCl_3$ (10 mmol) and the mixture refluxed again for 1.5-2 h. The completion of the reaction was checked by TLC. After that, ice-cold water (50 mL) was added to the reaction mixture and neutralized with 5% sodium bicarbonate solution; the solid that separated out was filtered, washed with water (10 mL) and dried. The product was recrystallised from suitable solvent to obtain **5/7**.

3-amino-5, 10 – dioxo – 1 – phenyl - 5, 10 – dihydro - 1H – pyrazolo [1, 2 - b]phthalazine-2-carbonitrile 5a: Yield 85%; m. p. 275-276 ^{o}C; HRMS calcd for $C_{18}H_{12}N_4O_2$ $[M+H]^+$: 317.09652. Found: 317.09380; IR (KBr, cm^{-1}) : 3191-3360 (-NH-), 2197 (-CN-), 1681 (-CO-), 1660 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 6.12 (s, 1H, -CH), 7.32-8.27 (m, 11H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 61.4, 62.9, 115.9, 126.6, 126.7, 127.2, 128.2, 128.4, 128.6, 128.7, 133.6, 134.6, 138.3, 150.5, 153.6, 156.6.

3-amino-5,10-dioxo-1-(2-chlorophenyl)-5,10-dihydro-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile 5b: Yield 82%; m. p.259-260 ^{o}C; HRMS calcd for $C_{18}H_{11}ClN_4O_2$ $[M+H]^+$: 351.18653. Found: 351.18967; IR (KBr, cm^{-1}) : 3181-3370 cm^{-1} (-NH-), 2190 (-CN-), 1683 (-CO-), 1662 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 6.20 (s, 1H, -CH), 7.22-8.22 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 61.3, 62.8, 115.3, 126.2, 126.5, 127.3, 128.1, 128.5, 128.7, 128.8, 133.3, 134.2, 138.2, 150.4, 153.5, 156.8.

3-amino-5,10-dioxo-1-(4-bromophenyl)-5,10-dihydro-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile 5c: Yield 83%; m. p.263-265 ^{o}C; HRMS calcd for $C_{18}H_{11}BrN_4O_2$ $[M+H]^+$: 395.28423. Found: 395.28034; IR (KBr, cm^{-1}) : 3190-3390 cm^{-1} (-NH-), 2180 (-CN-), 1689 (-CO-), 1669 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 6.10 (s, 1H, -CH), 7.30-8.28 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 61.0, 62.3, 115.5, 126.1, 126.2, 127.3, 128.2, 128.8, 128.9, 128.9, 133.4, 134.1, 138.3, 150.2, 153.4, 156.6.

3-amino-5,10-dioxo-1-(4-nitrophenyl)-5,10-dihydro-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile 5d: Yield 83%; m. p.229-230 ^{o}C; HRMS calcd for $C_{18}H_{11}N_5O_3$ $[M+H]^+$: 362.13310. Found: 362.13612; IR (KBr, cm^{-1}) : 3200-3410 cm^{-1} (-NH-), 2210 (-CN-), 1680 (-CO-), 1668 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 6.21 (s, 1H, -CH), 7.32-8.24 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 61.1, 62.4, 115.3, 126.0, 126.0, 127.2, 128.0, 128.5, 128.8, 128.9, 133.4, 134.0, 138.2, 150.1, 153.2, 156.5.

Ethyl 3-amino-5,10-dioxo-1-phenyl-5,10-dihydro-1H-pyrazolo[1,2-b]phthalazine-2-carboxylate 5e: Yield 82%; m. p.230-231 ^{o}C; HRMS calcd for $C_{20}H_{17}N_3O_4$ $[M+H]^+$: 364.13041. Found: 364.13441; IR (KBr, cm^{-1}) : 3180-3390 (-NH-), 1732 (-CO-), 1680 (-CO-), 1670 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 1.22 (t, 3H, $-CH_3$), δ 3.88 (t, 2H, $-CH_2$), δ 6.13 (s, 1H, -CH), 7.22-8.22 (m, 11H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 14.0, 58.9, 61.3, 61.8, 114.8, 124.5, 125.1, 128.0, 128.3, 128.3, 128.7, 128.8, 133.4, 134.3, 138.0, 150.2, 153.2, 156.5, 162.2.

Ethyl 3-amino-5,10-dioxo -1 - (2-chlorophenyl) -5, 10 –dihydro - 1H – pyrazolo [1,2-b] phthalazine-2-carboxylate 5f: Yield 84%; m. p.265-267 ^{o}C; HRMS calcd for $C_{20}H_{16}ClN_3O_4$ $[M+H]^+$: 398.24039. Found: 398.24339; IR (KBr, cm^{-1}) : 3162-3370 cm^{-1} (-NH-), 1722 (-CO-), 1685 (-CO-), 1674 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 1.12 (t, 3H, $-CH_3$), δ 3.98 (t, 2H, $-CH_2$), δ 6.03 (s, 1H, -CH), 7.22-8.23 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 14.2, 58.5, 61.5, 61.9, 114.3, 124.0, 124.2, 125.1, 126.2, 127.2, 127.4, 128.3, 132.3, 133.4, 137.1, 151.3, 153.3, 155.1, 160.2.

Ethyl 3-amino-5,10-dioxo -1 - (2-bromophenyl) -5, 10 –dihydro - 1H – pyrazolo [1,2-b] phthalazine-2-carboxylate 5g: Yield 82%; m. p.207-209 ^{o}C; HRMS calcd for $C_{20}H_{16}BrN_3O_4$ $[M+H]^+$: 442.13242. Found: 442. 13642; IR (KBr, cm^{-1}) : 3012-3360 cm^{-1} (-NH-), 1713 (-CO-), 1675 (-CO-), 1670 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 1.30 (t, 3H, $-CH_3$), δ 3.76 (t, 2H, $-CH_2$), δ 6.04 (s, 1H, -CH), 7.21-8.23 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 14.4, 56.6, 61.4, 61.7, 113.2, 120.3, 124.3, 124.9, 126.1, 126.7, 126.9, 128.2, 132.0, 133.3, 136.0, 150.2, 153.2, 154.0, 161.3.

Ethyl 3-amino-5,10-dioxo -1 - (2-nitrophenyl) -5, 10 –dihydro - 1H – pyrazolo [1,2-b] phthalazine-2-carboxylate 5h: Yield 83%; m. p. 232-233 ^{o}C; HRMS calcd for $C_{20}H_{16}N_4O_5$ $[M+H]^+$: 409.12567. Found: 409.12867; IR (KBr, cm^{-1}) : 3100-3364 cm^{-1} (-NH-), 1712 (-CO-), 1679 (-CO-), 1672 (-CO-) ; ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 1.20 (t, 3H, $-CH_3$), δ 3.86 (t, 2H, $-CH_2$), δ 6.02 (s, 1H, -CH), 7.21-8.23 (m, 10H, Ar-H & NH_2); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 14.2, 56.4, 61.2, 61.5, 113.1, 120.2, 124.4, 124.8, 126.4, 126.6, 126.8, 128.1, 132.1, 133.3, 136.0, 150.2, 153.1, 154.0, 161.0.

3,3-dimethyl-13-phenyl-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1,6,11(2H,13H)-trione 7a: Yield 88%; m. p. 203-205 ^{o}C; HRMS calcd for $C_{23}H_{20}N_2O_3$ $[M+H]^+$: 373.1268. Found: 373. 1238; IR (KBr, cm^{-1}) : 1661 (-CO-), 1625 (-CO-), 1601 (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.89-1.03 (s, 6H, -2CH_3), δ 2.05-2.54 (s, 4H, -2CH_2), δ 4.54 (s, 1H, -CH), 7.09-8.08 (m, 9H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 26.3, 28.7, 31.2, 31.8, 50.0, 114.4, 125.1, 126.1, 127.8, 128.0, 132.5, 144.2, 154.6, 162.8, 196.0.

3,3-dimethyl-13-(2-chlorophenyl)-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1,6,11(2H,13H)-trione 7b: Yield 86%; m. p. 268-270 ^{o}C; HRMS calcd for $C_{23}H_{19}ClN_2O_3$ $[M+H]^+$: 408.1453. Found: 408.1483; IR (KBr, cm^{-1}) : 1670 (-CO-), 1655 (-CO-), 1631 (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.99-1.04 (s, 6H, -2CH_3), δ 2.15-2.54 (s, 4H, -2CH_2), δ 4.53 (s, 1H, -CH), 7.19-8.08 (m, 8H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 24.4, 28.6, 30.1, 32.5, 50.3, 114.3, 124.2, 126.5, 127.4, 128.1, 131.4, 143.1, 153.3, 162.5, 196.1.

3,3-dimethyl-13-(4-bromophenyl)-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1,6,11(2H,13H)-trione 7c: Yield 84%; m. p. 262-264 ^{o}C; HRMS calcd for $C_{23}H_{19}BrN_2O_3$ $[M+H]^+$: 451.2372. Found: 451.2343; IR (KBr, cm^{-1}) : 1672 (-CO-), 1642 (-CO-), 1622 (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.91-1.34 (s, 6H, -2CH_3), δ 2.12-2.53 (s, 4H, -2CH_2), δ 4.50 (s, 1H, -CH), 7.14-8.14 (m, 8H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 24.2, 28.1, 30.2, 32.2, 50.2, 114.2, 123.2, 126.2, 127.3, 128.2, 131.0, 143.2, 153.2, 162.4, 196.1.

3,3-dimethyl-13-(2-nitrophenyl)-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1, 6, 11(2H, 13H)-trione 7d: Yield 85%; m. p. 239-240 ^{o}C; HRMS calcd for $C_{23}H_{19}N_3O_4$ $[M+H]^+$: 418.1330. Found: 418.1360; IR (KBr, cm^{-1}) : 1674 (-CO-), 1652 (-CO-), 1632 (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.92-1.24 (s, 6H, -2CH_3), δ 2.13-2.52 (s, 4H, -2CH_2), δ 4.52 (s, 1H, -CH), 7.16-8.04 (m, 8H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 24.3, 28.2, 30.2, 32.3, 50.2, 114.1, 123.2, 126.3, 127.3, 128.3, 131.1, 143.2, 153.2, 162.5, 196.2.

3,3-dimethyl-13-(3-nitrophenyl)-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1,6,11(2H,13H)-trione 7e: Yield 86%; m. p. 267-269 ^{o}C; HRMS calcd for $C_{23}H_{19}N_3O_4$ $[M+H]^+$: 418.1330. Found: 418.1372; IR (KBr, cm^{-1}) : 1672 (-CO-), 1662 (-CO-), 1651 (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.92-1.23 (s, 6H, -2CH_3), δ 2.13-2.54 (s, 4H, -2CH_2), δ 4.49 (s, 1H, -CH), 7.18-8.04 (m, 8H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 24.2, 28.0, 30.1, 32.3, 50.1, 114.1, 123.3, 126.4, 127.3, 128.2, 131.0, 143.1, 153.1, 162.4, 195.9.

3,3-dimethyl-13-(4-chlorophenyl)-3,4-dihydro-1H-indazolo[1,2-b]phthalazine-1,6,11(2H,13H)-trione 7f: Yield 83%; m. p. 258-259 ^{o}C; HRMS calcd for $C_{23}H_{19}ClN_2O_3$ $[M+H]^+$: 408.1453. Found: 408.1492; IR (KBr, cm^{-1}) : 1670 (-CO-), 1660 (-CO-), 1653 cm^{-1} (-CO-); ^{1}H- NMR (DMSO-d_6, 400 MHz): δ 0.99-1.24 (s, 6H, -2CH_3), δ 2.03-2.53 (s, 4H, -2CH_2), δ 4.44 (s, 1H, -CH), 7.14-8.03 (m, 8H, Ar-H); ^{13}C-NMR (DMSO-d_6, 100 MHz): δ 24.3, 28.5, 30.1, 32.3, 50.2, 114.3, 123.3, 126.2, 127.3, 128.2, 131.0, 143.3, 153.1, 162.4, 195.8.

References

i. S. S. El-Sakka, A. H. Soliman and A. M. Imam, Afinidad, 66, 167 (2009).

ii. L. Zhang, L. P. Guan, X. Y. Sun, C. X. Wei, K. Y. Chai and Z. S. Quan, Chem. Bio. Drug.Design. 73, 313 (2009).

iii. C.-K. Ryu, R.-E. Park, M.-Y and J.-H. Nho, Bioorg. Med. Chem. Lett. 17, 2577 (2007).

iv. J. Li, Y. F. Zhao, X. Y. Yuan, J. X. Xu and P. Gong, Molecules. 11, 574 (2006).

v. J. Sinkkonen, V. Ovcharenko, K. N. Zelenin, I. P. Bezhan, B. A. Chakchir, F. Al-Assar and K. Pihlaja, Eur. J. Org. Chem. 2046(2002).

vi. R. Ghahremanzadeh, S. Ahadi, M. Sayyafi and A. Bazgir, Tetrahedron

Lett. 49, 4479 (2008).
vii. (a) J. Li, Y. F. Zhao, X. Y. Yuvan, J. X. Xu and P. Gong, Molecules. 11, 574 (2006).
viii. R. Ghahremanzadeh, G. I. Shakibaei, A. Bazgir, Synlett. 8, 1129 (2008).
ix. M.R. Nabid, S.J. Tabatabaie, R. Gahremanzadeh and A. Bazgir, Ultrasonics Sonochemistry. 17 ,159(2010).
x. D. S. Raghuvanshi and K. N. Singh, Tetrahedron Letters. 52, 5702 (2011).
xi. H. R. Shaterian and M. Mohammadnia, J. Mole. Liquids, 173, 55 (2012).
xii. L.-P. Liu, J. M. Lu and M. Shi, M. Org. Lett. 9 (2007) 1303.
xiii. (a) Y. D. Reddy, Ch. V. R. Reddy and P. K. Dubey, RSC Adv. 4 , 2974 (2014) (b) Y. D. Reddy, Ch. V. R. Reddy and P. K. Dubey, Lett. Org. Chem. 11, 303(2014). (c) Y. D. Reddy, Ch. V. R. Reddy and P. K. Dubey, Green. Chem. Lett. and Rev. 7, 24 (2014).
xiv. Shaterian, H. R,; Mohammadnia, M. J. Mol. Liq. 173, 55 (2012).
xv. Khurana, J. M.; Magoo, D. Tetrahedron Lett. 50, 7300 (2009).
xvi. Shekouhy, M.; Hasaninejad, A. Ultrasonics Sonochemistry. 19, 307 (2012).
xvii. Hasaninejed, A, Kazerooni, M, R.; Zare, A. Catalysis Today. 196, 148 (2012).

Received on March 27, 2014.