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RESEARCH PAPER

A Facile Approach for One-Pot Synthesis of 1*H*-pyrazolo [1,2-*b*]phthalazine-5,10-dione Derivatives Catalyzed by $ZrCl_4$ as an Efficient Catalyst Under Solvent-Free Conditions

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Abstract A simple synthesis of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives via one-pot four-component condensation reaction of phthalimide, hydrazine monohydrate, aromatic aldehyde derivatives and malononitrile in the presence of a catalytic amount of zirconium tetrachloride ($ZrCl_4$) as a mild and efficient Lewis acidic catalyst under thermal and solvent-free conditions with good yields and short reaction times is developed. This present methodology has notable benefits such as high efficiency, inexpensive and non-toxic catalyst, environmentally benign nature, solvent-free conditions and simplicity of operation.

Keywords Zirconium tetrachloride ($ZrCl_4$) · Efficient Lewis acidic catalyst · 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives · Solvent-free conditions · Clean synthesis

1 Introduction

In recent years, multi-component domino reactions (MCRs) (Strecker 1850; Rezayati et al. 2015; Saberi 2015; Hasaninejad et al. 2015; Hashemi and Sardarian 2013; Esmaeilpour and Sardarian 2013; Mohamadpour et al. 2016a, b, 2015) have become one of the best approaches for economical and efficient synthesis of organic compounds. The special advantages of multi-component reactions include simple work-up, atom-economy, mild and environment-friendly, low cost, one-pot for the synthesis of organic compounds. Therefore, our recent studies focused on developing multi-component reactions.

Recently, the study for the synthesis of nitrogen-containing heterocyclic compounds such as 1*H*-pyrazolo[1,2-*b*] phthalazine-5,10-dione derivatives has attracted considerable interest of organic chemists because of their special biological (Genin et al. 2000; Singh et al. 2004) (Fig. 1) and pharmacological properties, for example, antibacterial (inhibitory activity against *Escherichia coli* FabH) (Lu et al. 2010), anticancer (Li et al. 2006), anti-inflammatory (Ryu et al. 2007), and cardiotonic (Nomoto et al. 1990).

Thus, recently, a number of procedures for the synthesis of 1*H*-pyrazolo[1,2-*b*] phthalazine-5, 10-dione derivatives have been reported that include Lewis and Brønsted acid catalysts, for example, $Ce(SO_4)_2.4H_2O$ (Mosaddegh and Hassankhani 2011), SBA-Pr-SO_3H (MohammadiZiarani et al. 2014), $InCl_3$ (VeeranarayanaReddy and TaeJeeong 2013), $NiCl_2.6H_2O$ (Song et al. 2012), [Bmim] OH (Raghuvanshi and Singh 2011), ultrasound-assisted (Nabid et al. 2010), *p*-TSA (Sayyafi et al. 2008), STA (Veeranarayana Reddy et al. 2014), CuI nanoparticles (Safaei-Ghomi et al. 2014), *p*-TSA/[Bmim]Br (Ghahremanzadeh et al. 2008), and TBBAD (Ghorbani-Vaghei et al. 2014). Some of these methodologies have limitations such as long time of reactions, low yields, toxic and expensive catalysts, difficult work-up, and use of strongly acidic conditions. Because of our interest in the development of environment-friendly procedures for synthesis of these heterocyclic compounds, we have reported $ZrCl_4$ as a mild and efficient catalyst for the one-pot synthesis of 1*H*-pyrazolo[1,2-b]phthalazine-5,10-dione derivatives from reaction between phthalimide (**1**, 1.0 mmol), hydrazine

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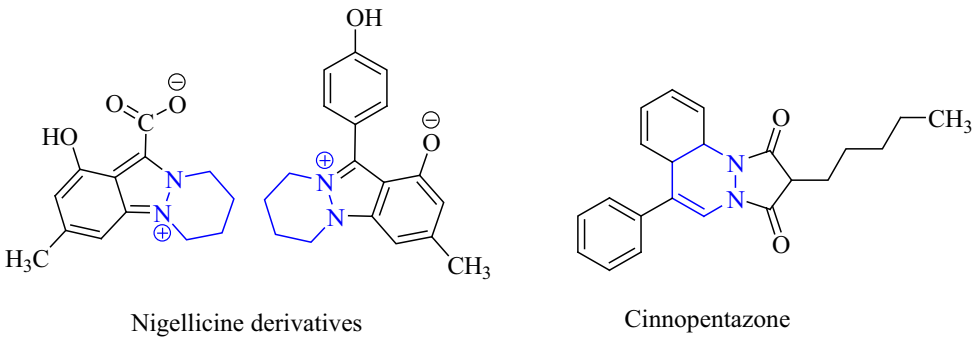
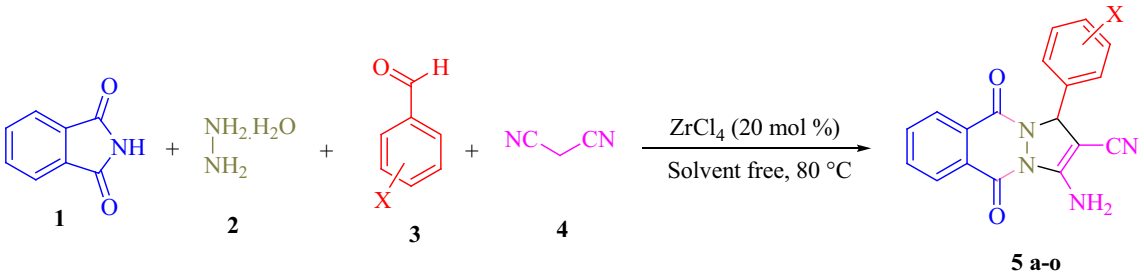


Fig. 1 Biologically active compounds with two-ring junction nitrogen atom



Scheme1 Synthesis of 1*H*-pyrazolo[1,2-*b*] phthalazine-5,10-dione derivatives

monohydrate (**2,** 1.0 mmol), aromatic aldehyde derivatives (**3**, 1.0 mmol) and malononitrile (**4**, 1.0 mmol) under thermal and solvent-free conditions (Scheme 1). During the past decades, the use of zirconium compounds as environmentally safe catalysts in organic synthesis has attracted great interest due to their notable advantages such as non-toxic, environment-friendly, easy to handle, high efficiency and low cost (Zhang and Li 2009; Zhang et al. 2007). The advantages of using $ZrCl_4$ as catalyst (Sajadikhah et al. 2015; Sharma et al. 2006) in organic compounds synthesis are mild, inexpensive, non-toxic, environmentally benign nature, and high catalytic activity. And we carried out the one-pot multi-component condensations by $ZrCl_4$ in good yields and short reaction times.

Furthermore, one of the sources of environmental pollutions is the usage of organic solvents under reflux conditions and the need of column chromatography to purify the products. In this present work, the products were obtained through simple filtering with no need for column chromatographic separation.

2 Experimental

2.1 General

Melting points of all compounds were determined using an Electrothermal 9100 apparatus. Also, nuclear magnetic resonance, ^{1}H NMR spectra were recorded on Bruker DRX-400 Avance instruments with DMSO-d_6 as solvents. In this work, all reagents and solvents purchased from Merck, Fluka and Acros chemical companies were used without further purification.

2.2 General procedure for preparation of pyrazolo[1,2-b]phthalazine-5,10-dione derivatives (5a–o)

A mixture of hydrazine monohydrate (**2**, 1.0 mmol), phthalimide (**1**, 1.0 mmol), and $ZrCl_4$ (20 mol%) was heated at 80 °C for 2 h. Then, malononitrile (**4**, 1.0 mmol) and aromatic aldehyde (**3**, 1.0 mmol) were added and the mixture of reaction was heated for appropriate time. After completion of the reaction (monitored by thin-layer chromatography, TLC), the mixture was cooled to rt, and the solid products were filtered and recrystallized from ethanol to give the corresponding products (**5a–o**). Spectra data of all products are represented below:

2.2.1 3-Amino-1-(phenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (5a)

Yellow powder; yield: 87 %; m.p. 268–270 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.14 (1H, s, $H_{benzylic}$), 7.33–7.48 (5H, m, H_{Ar}), 7.97–8.29 (6H, m, NH_2 and H_{Ar}).

*2.2.2 3-Amino-1-(4-bromophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5b**)*

Yellow powder; yield: 80 %; m.p. 266–268 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.14 (1H, s, $H_{benzylic}$), 7.46 (2H, d, $J = 11.2$ Hz, H_{Ar}), 7.58 (2H, d, $J = 11.2$ Hz, H_{Ar}), 7.70–8.29 (6H, m, NH_2 and H_{Ar}).

*2.2.3 3-Amino-1-(2-nitrophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5c**)*

Yellow powder; yield: 83 %; m.p. 262–264 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.62 (1H, s, $H_{benzylic}$), 7.61 (1H, t, $J = 9.6$ Hz, H_{Ar}), 7.73 (1H, t, $J = 9.6$ Hz, H_{Ar}), 7.85–7.91 (2H, m, H_{Ar}), 7.97–8.30 (6H, m, NH_2 and H_{Ar}).

*2.2.4 3-Amino-1-(4-methylphenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5d**)*

Yellow powder; yield: 91 %; m.p. 255–257 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 2.30 (3H, s, CH_3), 6.10 (1H, s, $H_{benzylic}$), 7.18 (2H, d, $J = 8.0$ Hz, H_{Ar}), 7.34 (2H, d, $J = 8.0$ Hz, H_{Ar}), 7.97–8.28 (6H, m, NH_2 and H_{Ar}).

*2.2.5 3-Amino-1-(2-chlorophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5e**)*

Yellow powder; yield: 81 %; m.p. 258–260 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.47 (1H, s, $H_{benzylic}$), 7.39–7.65 (4H, m, H_{Ar}), 7.91–8.31 (6H, m, NH_2 and H_{Ar}).

*2.2.6 3-Amino-1-(3-chlorophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5f**)*

Yellow powder; yield: 83 %; m.p. 267–269 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.15 (1H, s, $H_{benzylic}$), 7.39–7.41 (2H, m, H_{Ar}), 7.44–7.48 (1H, m, H_{Ar}), 7.65 (1H, s, H_{Ar}), 7.88–8.29 (6H, m, NH_2 and H_{Ar}).

*2.2.7 3-Amino-1-(2-thenaldehyde)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5g**)*

Yellow powder; yield: 88 %; m.p. 246–248 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.09 (1H, s, $H_{benzylic}$), 6.88–7.30 (4H, m, H_{Ar}), 7.96–8.28 (6H, m, NH_2 and H_{Ar}).

*2.2.8 3-Amino-1-(3-nitrophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5h**)*

Yellow powder; yield: 81 %; m.p. 270–272 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.35 (1H, s, $H_{benzylic}$), 7.57–7.90 (4H, m, H_{Ar}), 7.95–8.51 (6H, m, NH_2 and H_{Ar}).

*2.2.9 3-Amino-1-(3-methylphenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5i**)*

Yellow powder; yield: 94 %; m.p. 249–251 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 2.30 (3H, s, CH_3), 6.08 (1H, s, $H_{benzylic}$), 7.14–7.26 (4H, m, H_{Ar}), 7.97–8.29 (6H, m, NH_2 and H_{Ar}).

*2.2.10 3-Amino-1-(4-nitrophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5j**)*

Yellow powder; yield: 84 %; m.p. 226–228 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.30 (1H, s, $H_{benzylic}$), 7.62–7.92 (4H, m, H_{Ar}), 7.96–8.45 (6H, m, NH_2 and H_{Ar}).

*2.2.11 3-Amino-1-(4-fluorophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5k**)*

Yellow powder; yield: 93 %; m.p. 262-264 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.17 (1H, s, $H_{benzylic}$), 7.20 (2H, t, $J = 8.8$ Hz, H_{Ar}), 7.53–7.57 (2H, m, H_{Ar}), 7.96–8.26 (6H, m, NH_2 and H_{Ar}).

*2.2.12 3-Amino-1-(3,4,5-trimethoxyphenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5l**)*

Yellow powder; yield: 79 %; m.p. 251–253 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 3.66 (3H, s, OCH_3), 3.76 (6H, s, 2 × OCH_3), 6.07 (1H, s, $H_{benzylic}$), 6.78 (2H, s, H_{Ar}), 7.89–8.29 (6H, m, NH_2 and H_{Ar}).

*2.2.13 3-Amino-1-(3-methoxyphenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (**5m**)*

Yellow powder; yield: 82 %; m.p. 249–251 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 3.34 (3H, s, OCH_3), 6.09 (1H, s, $H_{benzylic}$), 6.88–7.30 (4H, m, H_{Ar}), 7.83–8.26 (6H, m, NH_2 and H_{Ar}).

2.2.14 3-Amino-1-(4-chlorophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (5n)

Yellow powder; yield: 86 %; m.p. 271–273 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.15 (1H, s, $H_{benzylic}$), 7.43 (2H, d, $J = 11.2$ Hz, H_{Ar}), 7.54 (2H, d, $J = 11.2$ Hz, H_{Ar}), 7.88–8.28 (6H, m, NH_2 and H_{Ar}).

2.2.15 3-Amino-1-(3-fluorophenyl)-5,10-dihydro-5,10-dioxo-1H-pyrazolo[1,2-b]phthalazine-2-carbonitrile (5o)

Yellow powder; yield: 91 %; m.p. 261–263 °C; ^{1}H NMR (400 MHz, DMSO-d_6): 6.16 (1H, s, $H_{benzylic}$), 7.16–7.20 (1H, m, H_{Ar}), 7.33 (1H, d, $J = 9.6$ Hz, H_{Ar}), 7.39–7.46 (2H, m, H_{Ar}), 7.84–8.29 (6H, m, NH_2 and H_{Ar}).

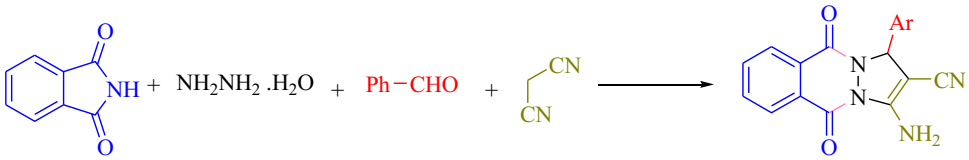
3 Results and Discussion

To carry out the preparation of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives in a more efficient way, the reaction of phthalimide, hydrazine monohydrate, benzaldehyde and malononitrile was selected as a model system under thermal solvent-free conditions to find optimization of reaction conditions. The preparation of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives was studied at different amounts of $ZrCl_4$ as a mild and efficient Lewis acidic catalyst (5, 10, 15, 20 and 25 mol%) and different reaction temperatures (rt, 40, 60, 80 and 100 °C) (Table 1). The reaction did not occur in the absence of catalyst (Table 1, entry 1). The best result was obtained using 20 mol % of $ZrCl_4$ at 80 °C (Table 1, entry 5). Using the optimized reaction conditions, the scope and efficiency of these procedures were explored for the synthesis of a wide variety of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives. The results are summarized in Table 2. As shown in Table 2, the direct four-component reactions worked well with a variety of arylaldehydes including those bearing electron-withdrawing and electron-donating groups such as Cl, Br, NO_2, OMe, …, and the desired compounds were obtained in good to excellent yields. This methodology offers significant improvements such as simplicity in operation with no necessity of chromatographic purification steps, low-cost and eco-friendly catalyst.

The chemical structures of compounds (Table 2) were confirmed by melting point and ^{1}H NMR spectroscopy. The structure of products was proved by comparison of spectroscopic data of some products with those of authentic samples (Table 3).

The proposed mechanism for the catalytic synthesis of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives in the presence of $ZrCl_4$ is shown in Scheme 2. First, the reaction of phthalimide (**1**) with hydrazine monohydrate (**2**) produced phthalhydrazide (**A**). Next, in the catalytic system, the Knoevenagel-type coupling of arylaldehyde (**3**) and malononitrile (**4**) give rise to intermediate (**B**). Then, the subsequent 1,4-conjugate addition of phthalhydrazide (**A**) to the activated intermediate (**B**) followed by cyclization and tautomerization affords the corresponding product **5**.

Table 1 Optimization of the reaction condition for the synthesis of pyrazolo[1,2-*b*]phthalazine-5,10-dione **5a**



Entry	$ZrCl_4$ (mol%)	Temperature (°C)	Time (h)	Isolated yields (%)
1	Catalyst-free	80	14	Not product
2	5	80	10	31
3	10	80	7	56
4	15	80	5	73
5	**20**	**80**	**4**	**87**
6	20	rt	14	Not product
7	20	40	8	21
8	20	60	6	53
9	20	100	4	87
10	25	80	4	89

Reaction conditions: phthalimide, hydrazine monohydrate, benzaldehyde and malononitrile and $ZrCl_4$ were heated at 80 °C

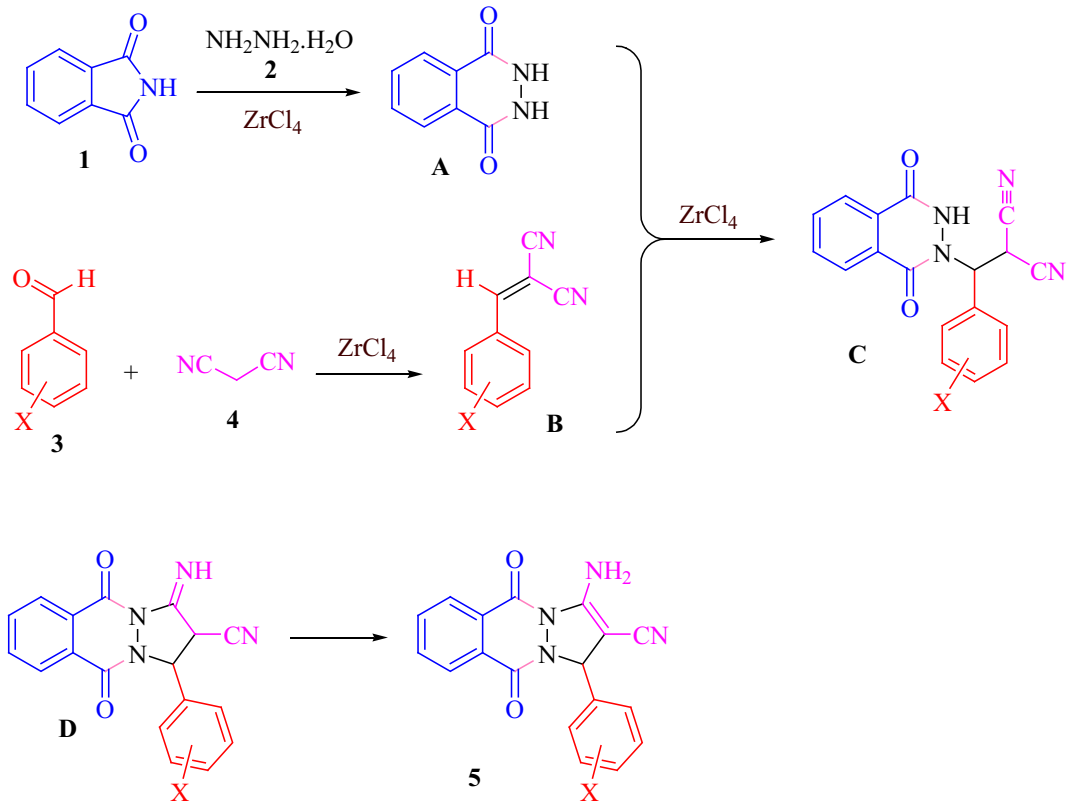
Table 2 $ZrCl_4$-catalyzed synthesis of pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives under solvent-free conditions

Entry	Ar	Product	Time (h)	Isolated yields (%)	M.p. °C	Lit. M.p. °C
1	C_6H_5	**5a**	4	87	268–270	270–272 (Safaei-Ghomi et al. 2014)
2	4-Br-C_6H_4	**5b**	5	80	266–268	265–267 (MohammadiZiarani et al. 2014)
3	2-NO_2-C_6H_4	**5c**	3.5	83	262–264	265–266 (MohammadiZiarani et al. 2014)
4	4-Me-C_6H_4	**5d**	3	91	255–257	253–255 (Safaei-Ghomi et al. 2014)
5	2-Cl-C_6H_4	**5e**	4.5	81	258–260	257–259 (Veeranarayana Reddy et al. 2014)
6	3-Cl-C_6H_4	**5f**	5	83	267–269	266–267 (MohammadiZiarani et al. 2014)
7	C_4H_3S	**5g**	4.5	88	246–248	244–246 (Safaei-Ghomi et al. 2014)
8	3-NO_2-C_6H_4	**5h**	4	81	270–272	269–271 (Ghahremanzadeh et al. 2008)
9	3-Me-C_6H_4	**5i**	3	94	249–251	250–252 (Safaei-Ghomi et al. 2014)
10	4-NO_2-C_6H_4	**5j**	4	84	226–228	228–229 (Veeranarayana Reddy et al. 2014)
11	4-F-C_6H_4	**5k**	2.5	93	262–264	263–265 (MohammadiZiarani et al. 2014)
12	3,4,5-$(OMe)_3$-C_6H_2	**5l**	4	79	251–253	253–255 (Veeranarayana Reddy et al. 2013)
13	3-OMe-C_6H_4	**5m**	3	82	249–251	248–251 (Nabid et al. 2010)
14	4-Cl-C_6H_4	**5n**	5	86	271–273	270–272 (Ghahremanzadeh et al. 2008)
15	3-F-C_6H_4	**5o**	2	91	261–263	263–265 (Veeranarayana Reddy et al. 2014)

Table 3 Comparison of ^{1}HNMR data for synthesis of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives

Entry	Product	H Shift (found)	H Shift (lit)	References
1	**5a**	6.14 (1H, s, $H_{benzylic}$)	6.12 (1H, s, $H_{benzylic}$)	(Ghorbani-Vaghei et al. 2014)
		7.33–7.48 (5H, m, H_{Ar})	7.29–7.47 (5H, m, H_{Ar})	
		7.97–8.29 (6H, m, NH_2 and H_{Ar})	7.80–8.3 (6H, m, NH_2 and H_{Ar})	
2	**5d**	2.30 (3H, s, CH_3)	2.28 (3H, s, CH_3)	(Safaei-Ghomi et al. 2014)
		6.10 (1H, s, $H_{benzylic}$)	6.07 (1H, s, $H_{benzylic}$)	
		7.18 (2H, d, $J = 8.0$ Hz, H_{Ar})	7.14–7.33 (4H, m, H_{Ar})	
		7.34 (2H, d, $J = 8.0$ Hz, H_{Ar}) 7.97-8.28 (6H, m, NH_2 and H_{Ar})	7.94–8.25 (6H, m, NH_2 and H_{Ar})	
3	**5e**	6.47 (1H, s, $H_{benzylic}$)	6.46 (1H, s, $H_{benzylic}$)	(Nabid et al. 2010)
		7.39–7.65(4H, m, H_{Ar})	7.33–7.62 (4H, m, H_{Ar})	
		7.91–8.31 (6H, m, NH_2 and H_{Ar})	7.87–8.30 (4H, m, H_{Ar})	
			8.15 (2H, s, NH_2)	
4	**5i**	2.30 (3H, s, CH_3)	2.27 (3H, s, CH_3)	(Safaei-Ghomi et al. 2014)
		6.08 (1H, s, $H_{benzylic}$)	6.05 (1H, s, $H_{benzylic}$)	
		7.14–7.26 (4H, m, H_{Ar})	7.12–7.24 (4H, m, H_{Ar})	
		7.97–8.29 (6H, m, NH_2 and ArH).	7.96–8.26 (6H,m,Ar and NH_2)	
5	**5l**	3.66 (3H, s, OCH_3)	3.64–3.73 (9H, s, OCH_3)	(Ghorbani-Vaghei et al. 2014)
		3.76 (6H, s, 2 × OCH_3)	6.05 (1H, s, $H_{benzylic}$)	
		6.07 (1H, s, $H_{benzylic}$)	6.75 (2H, s, ArH)	
		6.78 (2H, s, H_{Ar})	7.94–8.26 (6H, m, NH_2 and H_{Ar}).	
		7.89–8.29 (6H, m, NH_2 and H_{Ar}).		
6	**5n**	6.15 (1H, s, $H_{benzylic}$)	6.14 (1H, s, $H_{benzylic}$)	(Safaei-Ghomi et al. 2014)
		7.43 (2H, d, $J = 11.2$ Hz, H_{Ar})	7.39–7.52 (4H, m, H_{Ar})	
		7.54 (2H, d, $J = 11.2$ Hz, H_{Ar})	7.94–8.26 (6H, m, NH_2 and H_{Ar})	
		7.88–8.28 (6H, m, NH_2 and H_{Ar})		

Comparison of catalytic ability of some of the catalysts reported in the literature for the synthesis of 1*H*-pyrazolo[1,2-b]phthalazine-5,10-dione derivatives is shown in Table 4. This study reveals that $ZrCl_4$ has shown its extraordinary potential to be an alternative mild, low-cost and eco-friendly catalyst for the synthesis of these compounds; in addition to the use of solvent-free conditions, excellent yield and short reaction times in the



Scheme 2 Proposed mechanistic route for the synthesis of pyrazolo[1,2-b]phthalazine-5,10-dione derivatives

Table 4 Comparison of catalytic ability of some of the catalysts reported in the literature for the synthesis of 1*H*-pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives

Entry	Catalyst	Conditions	Time/yield (%)	References
1	Saccharin	Solvent-free, 90 °C	3 h/89	(Mohamadpour et al. 2016a)
2	$InCl_3$	Water, Reflux	1.5 h/85	(Veeranarayana Reddy et al. 2013)
3	$NiCl_2.6H_2O$	EtOH, Reflux	3 h/87	(Song et al. 2012)
4	*p*-TSA	[Bmim]Br, 100 °C	3 h/94	(Sayyafi et al. 2008)
5	STA	Solvent-free, 70 °C	20 min/94	(Veeranarayana Reddy et al. 2014)
6	CuI nanoparticles	MeCN, Reflux	27 min/91	(Safaei-Ghomi et al. 2014)
7	TBBAD	Solvent-free, 80-100 °C	15 min/89	(Ghorbani-Vaghei et al. 2014)
8	$ZrCl_4$	Solvent-free, 80 °C	4 h/87	This work

Based on the four-component reaction of benzaldehyde, phthalimide, hydrazine monohydrate and malononitrile

reaction are the notable advantages of this present methodology.

4 Conclusion

In summary, zirconium tetrachloride ($ZrCl_4$) as an efficient, eco-friendly Lewis acidic catalyst for the one-pot four-component clean synthesis of pyrazolo[1,2-*b*]phthalazine-5,10-dione derivatives by means of phthalimide, hydrazine monohydrate and the type of aldehydes derivatives, malononitrile under thermal and solvent-free conditions with excellent yields and short reaction times is studied. The notable advantages of the present methodology are low-cost and non-toxic catalyst, eco-friendly, mild, one-pot, highly efficient, environmentally benign nature, simplicity of operation with no necessity of chromatographic purification steps and solvent-free conditions.

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