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# Green synthesis of substituted 2-thioxoimidazolidine-4,5-dione using benzoyl chloride

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**Abstract:** A novel, convenient and efficient approach to the synthesis of 2-thioxoimidazolidine-4,5-dione derivatives *via* the reaction between benzoyl chloride, ammonium thiocyanate, primary amines and diethyl oxalate in water at room temperature is described. The method offers several advantages including high yields of products and performing reaction under solvent-free conditions.

**Keywords:** Primary amines, Imidazole, Isothiocyanate, Alkyl propiolate,Oxalyl chloride.

## Introduction

One of the best procedures for the preparation of intricate compounds by employing of simple reagents is multicomponent reactions (MCRs) [1-5]. The prepared compounds by using MCRs are pleasurable for medicinal and synthetic chemists [6-8]. Furthermore, green method is employed for saving resources and reducing of prices of used procedure. Utilizing of eco-friendly and ecologically solvents rather than harmful organic solvents and economical starting materials are important points for the developing of green preparation of organic compounds [9]. Five membered heterocycles with a nitrogen atom, such as pyrroles and imidazoles, are important building blocks in a wide number of biologically active compounds [10-15]. Among them, pyrroles are heterocycles of great importance because of their frequent presence in natural products similar to heme, chlorophyll, vitamin $B_{12}$, and various cytochrome enzymes [16].

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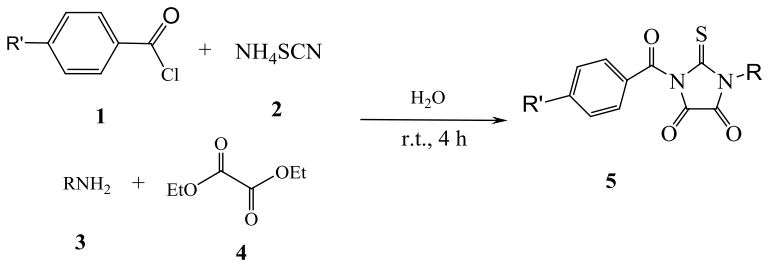
Some recently isolated pyrrole containing marine natural products have been found to display significant cytotoxicity and function as multidrug resistance (MDR) reversal agents [17].Many of these biologically active compounds function as chemotherapeutic agents. Also, the imidazole system can be found in numerous medically relevant compounds, such as the fungicide Ketoconazole [18] and its family members, the benzodiazepine antagonist Flumazenil [19], the antineoplastic drug Dacarbazine [20], the antibiotic Metronidazole [21], the antiulcerative agent Cimetidine [22], the antihyperthyroid drug Methimazole [23], the rohormone Thyroliberin [24], the muscarinic receptor agonist Pilocarpine [25] and the hypnotic agent etomidate [26]. Our research group reported the synthesis of a series of 2-thioxoimidazolidine-4,5-dione **5** using the reaction of benzoyl chloride **1**, ammonium thiocyanate **2**, primary amines **3** and diethyl oxalate **4** in water in good yields (Scheme **1**).

## Results and discussion

In this research the four component reactions of benzoyl chloride **1**, ammonium thiocyanate **2**, primary amines **3** and diethyl oxalate **4** in water produced 2-thioxoimidazolidine-4,5-dione **5** in good yields (Scheme **1**).

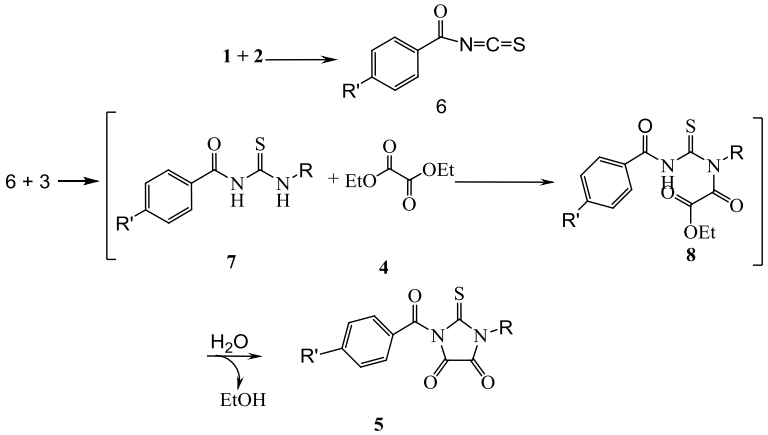



| 5 | R | R' | Yield (%) of **5** |
|---|---|---|---|
| **a** | Bn | Me | 90 |
| **b** | 4-$MeC_6H_4CH_2$ | OMe | 92 |
| **c** | 4-$MeOC_6H_4CH_2$ | Me | 90 |
| **d** | *n*-Bu | $NO_2$ | 85 |
| **e** | Et | OMe | 87 |

**Scheme 1:** Synthesis of compound **4** using primary amine, isothiocyanate and diethyl oxalate.

The structures of compounds **5** were assigned by IR, $^1$H NMR, $^{13}$C NMR and mass spectral data, and these data were showed in supporting information. For example, the $^1$H NMR spectrum of **5a** exhibited one singlet for methyl protons at ($\delta$ 2.35) and one singlet for $NCH_2$ protons at ($\delta$ 5.14) along with signals for an aromatic moiety. Three resonances at 154.3 (C=O), 156.7 (C=O), and 183.6 (C=S) ppm were observed in the $^{13}$C NMR spectrum of **5a**, which is attributed to the carbonyl and thionyl groups, further confirming the proposed structure.

Although we have not established the mechanism of the reaction between the amines and aryisothiocyanate in the presence of oxalyl chloride in an experimental manner, a possible explanation is proposed in Scheme **2**. Compound **5** result from the initial addition of the amine to in situ production of isothiocyanate **6** and subsequent attack of the resulting reactive compound **7** on the oxalyl chloride to yield intermediate **8**. Cyclization of the intermediate **8** by elimination of EtOH and $H_2O$ leads to compound **5**.




**Scheme 2:** Proposed mechanism for the synthesis of compound **5**.

## Conclusion

In conclusion, we reported a novel method involving primary amines and isothiocyanate in the presence of oxalyl chloride for the synthesis of 1*H*-imidazole derivatives. The advantages of our work are that the reaction is performed in water without using a catalyst.

## Experimental Section

*General*

Melting points were taken on a Kofler hot stage apparatus and are uncorrected. $^{1}$H, $^{13}$C and $^{31}$P NMR spectra were obtained with a Bruker FT-500 spectrometer in $CDCl_3$, and tetramethylsilane (TMS) was used as an internal standard or 85% $H_3PO_4$ as external standard. Mass spectra were recorded with a Finnigan Mat TSQ-70 spectrometer. Infrared (IR) spectra were acquired on a Nicolet Magna 550-FT spectrometer. Elemental analyses were carried out with a Perkin-Elmer model 240-C apparatus. The results of elemental analyses (C, H, N) were within ±0.4 % of the calculated values. Acetylenic ester, phenacyl bromide or its derivatives and triphenylphosphine were obtained from Fluka and were used without further purification.

***General procedure for preparation of compounds 4a-e.***

To a mixture of primary amine **1** (2 mmol) and *in situ* production of arylisothiocyanate **6** (2 mmol) was added diethyl oxalate **3** (2.5 mmol) at room temperature. The reaction mixture was then stirred for 4 h. After completion of the reaction [TLC (AcOEt/hexane, 1:4 v/v) monitoring], the reaction mixture was purified by flash column chromatography on silica gel (Merck 230–400 mesh) using *n*-hexane–EtOAc as eluent to afforded pure compounds **5** (Scheme **2**).

***1-Benzyl-3-(4-methylphenyl)-2-thioxodihydro-1H-imidazole-4,5-dione (5a):***

Yellow powder, m.p. 158-160°C, yield: 0.53g (85%), IR (KBr) ($\nu_{max}$/cm$^{-1}$): 1764, 1735, 1666, 1441, 1340 cm$^{-1}$. $^{1}$H NMR (500.1 Hz, $CDCl_3$): $\delta$ = 2.35 (3 H, s, Me), 5.14 (2 H, s, N-$CH_2$), 7.28 (1 H, d, $^{3}J$ = 7.2 Hz, CH), 7.32 (2 H, t, $^{3}J$ = 7.6 Hz, 2 CH), 7.38 (2 H, d, $^{3}J$ = 7.3 Hz, 2 CH), 7.41 (2 H, d, $^{3}J$ = 7.3 Hz, 2 CH), 7.52 (2 H, d, $^{3}J$ = 7.4 Hz, 2 CH) ppm. $^{13}$C NMR (125.7 Hz, $CDCl_3$): $\delta$ = 22.4 (Me), 45.6 (N-$CH_2$), 117.5 (2 CH), 128.2 (CH), 129.0 (2 CH), 129.2 (2 CH), 132.4 (2 CH), 133.2 (C), 137.5 (C), 139.4 (C), 154.3 (C=O), 156.7 (C=O), 183.6 (C=S) ppm. MS: *m*/*z* (%) = 310 ($M^+$, 10), 219 (68), 91 (100), 77 (60). Anal. Calc. for $C_{17}H_{14}N_2O_2S$ (310.37): C, 65.79; H, 4.55; N, 9.03. found: C, 65.83; H, 4.62; N, 9.14%.

***1-(4-Methylbenzyl)-3-(4-methoxyphenyl)-2-thioxodihydro-1H-imidazole-4,5-dione (5b):***

Pale yellow powder, m.p. 168-170°C, yield: 0.54g (80%), IR (KBr) ($\nu_{max}$/cm$^{-1}$): 1759, 1748, 1667, 1443, 1347 cm$^{-1}$. $^{1}$H NMR (500.1 Hz, $CDCl_3$): $\delta$ = 2.34 (3 H, s, Me), 5.12 (2 H, s, N-$CH_2$), 7.15 (2 H, d, $^{3}J$ = 7.8 Hz, 2 CH), 7.24 (2 H, d, $^{3}J$ = 7.5 Hz, 2 CH),7.34 (2 H, d, $^{3}J$ = 7.8 Hz, 2 CH), 7.42 (2 H, d, $^{3}J$ = 7.5 Hz, 2 CH) ppm. $^{13}$C NMR (125.7 Hz, $CDCl_3$): $\delta$ = 22.5 (Me), 46.7 (N-$CH_2$), 55.3 (MeO), 114.6 (2 CH), 128.5 (2 CH), 129.4 (2 CH), 131.8 (C), 132.2 (2 CH), 136.4 (C), 139.3 (C), 155.2 (C=O), 155.8 (C=O), 160.4 (C), 180.4 (C=S) ppm. Anal. Calc. for $C_{18}H_{16}N_2O_3S$ (340.39): C, 63.51; H, 4.74; N, 8.23. found: C, 63.62; H, 4.83; N, 8.32%.

***1-(4-Methoxybenzyl)-3-(4-methylphenyl)-2-thioxodihydro-1H-imidazole-4,5-dione (5c):***

Yellow powder, m.p. 165-167°C, yield: 0.37g (87%), IR (KBr) ($\nu_{max}$/cm$^{-1}$): 1764, 1735, 1670, 1445, 1340 cm$^{-1}$. $^{1}$H NMR (500.1 Hz, $CDCl_3$): $\delta$ = 2.36 (3 H, s, Me), 5.15 (2 H, s, N-$CH_2$), 7.18 (2 H, d, $^{3}J$ = 7.6 Hz, 2 CH), 7.28 (2 H, d, $^{3}J$ = 7.9 Hz, 2 CH), 7.38 (2 H, d, $^{3}J$ = 7.9 Hz, 2 CH), 7.45 (2 H, d, $^{3}J$ = 7.6 Hz, 2 CH) ppm. $^{13}$C NMR (125.7 Hz, $CDCl_3$): $\delta$ = 22.2 (Me), 47.3 (N-$CH_2$), 55.5 (MeO), 113.8 (2 CH), 128.8 (2 CH), 129.6 (2 CH), 132.3 (C), 132.8 (2 CH), 135.7 (C), 138.4 (C), 155.3 (C=O), 156.2 (C=O), 161.3 (C), 181.7 (C=S) ppm. Anal. Calc. for $C_{18}H_{16}N_2O_3S$ (340.39): C, 63.51; H, 4.74; N, 8.23. found: C, 63.65; H, 4.84; N, 8.30%.

***1-butyl-3-(4-nitrophenyl))-2-thioxodihydro-1H-imidazole-4,5-dione (5d):***

Yellow powder, mp: 137-139 °C, yield: 0.46g (75 %). IR (KBr) ($\nu_{max}$/cm$^{-1}$): 1764, 1742, 1675, 1443, 1348 cm$^{-1}$. $^{1}$H NMR (500.1 Hz, $CDCl_3$): $\delta$ = 1.12 (3 H, t, $^{3}J$ = 7.4 Hz, $CH_3$), 1.38 (2 H, m, $CH_2$), 1.52 (2 H, m, $CH_2$), 4.58 (2 H, s, N-$CH_2$), 7.76 (2 H, d, $^{3}J$ = 7.8 Hz, 2 CH), 8.37 (2 H, d, $^{3}J$ = 7.8 Hz, 2 CH) ppm. $^{13}$C NMR (125.7 Hz, $CDCl_3$): $\delta$ = 13.4 ($CH_3$), 19.4 ($CH_2$), 28.4 ($CH_2$), 43.7 (N-$CH_2$), 118.7 (2 CH), 128.5 (2 CH), 140.2 (C), 142.3 (C), 155.2 (C=O), 155.4 (C=O), 178.6 (C=S) ppm. Anal. Calc. for $C_{13}H_{13}N_3O_4S$ (307.33): C, 50.81; H, 4.26; N, 13.67. found: C, 50.92; H, 4.36; N, 13.72%.

***1-Ethyl-3-(4-methoxyphenyl))-2-thioxodihydro-1H-imidazole-4,5-dione (5e):***

Yellow powder, m.p. 140-142 °C, yield: 0.39g (75 %), IR (KBr) ($\nu_{max}$/cm$^{-1}$): 1765, 1742, 1665, 1487, 1345 cm$^{-1}$. $^1$H NMR (500.1 Hz, $CDCl_3$): $\delta$ = 1.28 (3 H, t, $^3J$ = 7.3 Hz, $CH_3$), 3.85 (3 H, s, MeO), 3.87 (2 H, q, $^3J$ = 7.4 Hz, $NCH_2$), 7.24 (2 H, d, $^3J$ = 7.6 Hz, 2 CH), 7.35 (2 H, d, $^3J$ = 7.6 Hz, 2 CH) ppm. $^{13}$C NMR (125.7 Hz, $CDCl_3$): $\delta$ = 13.4 ($CH_3$), 36.7 (NCH2), 55.6 (MeO), 113.4 (2 CH), 132.4 (2 CH), 133.7 (C), 153.7 (C=O), 155.6 (C=O), 159.4 (C), 182.5 (C=S) ppm. Anal. Calc. for $C_{12}H_{12}N_2O_3S$ (264.30): C, 54.30; H, 4.58; N, 10.60. found: C, 54.42; H, 4.63; N, 10.70%.

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