NEW ROUTE FOR THE SYNTHESSES OF SOME NOVEL DERIVATIVES OF 3-ARYL BENZO[d]THIAZOLE-2(3H)-IMINE FROM HIGH SUBSTITUTED THIOUREAS

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ABSTRACT

We have developed herein a new approach to the diverse synthesis of novel derivatives of 3-aryl benzo[d]thiazole-2(3H)-imines (3a-g), by a two-component reaction between diazonium salt (2) and various synthesized N-acyl-N'-aryl thioureas (1a-g), in the presence of sodium tert-butoxide as strong base. Finally, it resulted in the production of the desired products with a moderate yield. The chemical structures of these synthesized compounds were confirmed by various physico-chemical methods viz. FT-IR, 1H-NMR, 13C-NMR, and elemental analysis.

Keywords: 3-aryl benzo[d]thiazole-2(3H)-imines, Diazonium salt, N- acyl-N'-aryl thiourea.

INTRODUCTION

Fused heterocyclic compounds are the key valuable and structural scaffolds in a broad variety of natural products, drug molecules, and functional materials [1–3]. Among them, the analogues of benzothiazole and its derivatives have a significant role due to their wide variety of biological activities and applications in the pharmaceutical industry. Benzothiazole is an organosulfur, as well as organonitrogen heterocyclic compound that act as core nucleus in various drugs such as anticancer [5,14], antileishmanial [15], antimicrobial [9,16], anti-asthmatic [11], antitumor [6], antibacterial [17,18], anti-tubercular [19] anticonvulsant [4,20], anti-HIV [15,21], anti-inflammatory [5,7], antifungal [9,13], antiproliferative [6,14,21,22], antiviral [23], anti-Alzheimer [10,14], antimalarial [15], and anti-diabetic [24–26] effects. The related research and developments in BTA-based medicinal chemistry have become a rapidly developing and increasingly active topic [6,19].

Various methods have been reported for the synthesis of benzothiazole derivatives. A survey of the literature showed that there are limited means to generate them. Nevertheless, some methods suffer from disadvantages such as high temperature, long reaction time, tedious work-up procedures, use of toxic metallic compounds, toxic and volatile solvents, and chromatographic separation. As a consequence, designing environmentally benign methods is a challenge for researchers. In recent decades, great efforts have been devoted to exploring novel, convenient, and efficient synthetic routes [27–29].

Thiourea and its derivatives with the general formula (R'RN) (R'R'N)CS, are a valuable functional group in organic chemistry. Thioureas are used as the building blocks in the preparation of the heterocyclic compounds. Therefore, the syntheses of its derivatives have been the subject of gained interest as a precursor of the wide variety of biologically active compounds for many years [30–32]. Herein, we have prepared N-acyl-N'-aryl thiourea derivatives by the reaction of acyl halides, ammonium thiocyanate, and aryl amines with satisfactory yields. The reaction was performed under reflux conditions.

Diazonium compounds have been investigated extensively since the first one reported in 1858. They can be used as valuable building blocks or intermediates in a wide range of organic syntheses. Generally, the synthesis of an aromatic diazonium salt is initiated by the diazotization of an aromatic amine with sodium nitrite and a mineral acid. Nevertheless, the diazonium salts are most generally used in situ without isolation due to their extremely dangerous nature rising from low thermal stability and chemical instability [33–35].

In this study for the first time, we reported a new route for the synthesis of some 3-aryl benzo[d]thiazole-2(3H)-imine derivatives. At the first stage of the survey, we optimized the synthesis method of the compound from accessible reagents. Finally, target products were developed through reaction different types of synthesized N-acyl-N'-aryl thiourea derivatives with a diazonium salt in the presence of an excess of sodium tert-butoxide as a bulky strong non-nucleophilic base with moderate yield [36–38]. The results of this study and the details of the employed methodology are mentioned in the next sections.

EXPERIMENTAL

Chemicals and reagents

All chemicals used in this study are of high analytical grade. They were obtained from (either Sigma-Aldrich or Merck). In all cases, the product's structure was identified by their FT-IR, 1H- and 13C-NMR. The purification of products was performed via recrystallization by n-hexane. All the melting points were measured with an electro thermal type 9100 melting points apparatus and have not been corrected. Thin-layer chromatography (TLC) was performed using HF254 fluorescent silica gel plates (Merck), and spots were detected under UV light at 254 nm. Infrared spectra (IR: ν/cm–1) were obtained on Shimadzu IR-470, using KBr disks. 1H-NMR and 13C-NMR spectra were recorded at 293 K on a Bruker Avance DRX-250 (250 MHz) spectrometer. NMR spectra were acquired in base-filtered deuterated chloroform (CDCl3) solvents containing Tetramethylsilane (TMS) as an internal standard at 250.1 MHz and 62.8 MHz. Elemental analyses were carried out on a Carlo-Erba EA1110 CNNO-S analyzer and agreed with calculated values.

General procedure for the preparation of 3-aryl benzo[d]thiazole-2(3H)-imine derivatives (3a–g)

Thiourea derivatives (1a–g) and the diazonium salt (2) were prepared by the previously reported chemical techniques [39–41]. To a vigorously stirred cold (0–5 °C) solution of yellow diazonium crystals (2), a solution of thiourea (1a) 0.256 g (1 mmol) in acetone (15 ml) added slowly in sodium tert-butoxide media for 20 min. The reaction mixture was allowed to stir vigorously under controlled temperature at 0–5 °C for 2–3 hrs. In the following, the reaction mixture was stirred under reflux conditions for further 45 min to complete the reaction. The progress of the reaction was monitored by TLC using n-hexane: ethyl acetate (3:1) as eluent to confirm the accuracy.

Upon completion of the reaction, washing and purification operations were carried out, then the synthesized compound was separated by simple filtration and purified by recrystallization from n-hexane, at high purity. After drying, pure light brown solid (3a) with melting point 114–116 °C and yield 74 %. The chemical structures of the product has been confirmed by various physico-chemical methods viz. FT-IR, 1H-NMR, 13C-NMR and elemental analysis, accordingly the other desired derivatives were prepared by the same method. The synthetic route to compounds (3a–g) is outlined in Scheme 1.
The structure and physical data of products are presented in Table 1.

### Table 1. The structure and physical data of products

<table>
<thead>
<tr>
<th>Entry</th>
<th>Thiourea no.</th>
<th>Product *</th>
<th>m.p. (°C)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1a</td>
<td><img src="image1" alt="Image" /></td>
<td>114–116</td>
<td>74</td>
</tr>
<tr>
<td>2</td>
<td>1b</td>
<td><img src="image2" alt="Image" /></td>
<td>109–111</td>
<td>73</td>
</tr>
<tr>
<td>3</td>
<td>1c</td>
<td><img src="image3" alt="Image" /></td>
<td>115–117</td>
<td>68</td>
</tr>
<tr>
<td>4</td>
<td>1d</td>
<td><img src="image4" alt="Image" /></td>
<td>105–107</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>1e</td>
<td><img src="image5" alt="Image" /></td>
<td>106–109</td>
<td>79</td>
</tr>
<tr>
<td>6</td>
<td>1f</td>
<td><img src="image6" alt="Image" /></td>
<td>115–117</td>
<td>75</td>
</tr>
<tr>
<td>7</td>
<td>1g</td>
<td><img src="image7" alt="Image" /></td>
<td>Unknown (decomp. ≥ 180)</td>
<td>70</td>
</tr>
</tbody>
</table>

*Compounds were prepared in the presence of sodium tert-butoxide

* Isolated yields

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**Physical and spectroscopic data for products (3a–g)**

**3-phenyl benzo[d]thiazole-2(3H)-imine (3a)**

Light brown solid; yield: 74 %, m.p.: 114–116 °C, FT-IR (KBr): 3306 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.03–7.67 (9H, m, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 117.8, 122.1, 126.7, 127.6, 128.3, 129.3, 129.9, 131.1, 131.7, 133.2, and 135.8. Anal. For C\(_{15}\)H\(_{12}\)N\(_2\)S (226) Calcd.: C 65.03; H 4.42; N 12.39; S 14.16 %. Found: C 66.09; H 4.45; N 12.43; S 14.15 %.

**3-(4-chlorophenyl) benzo[d]thiazole-2(3H)-imine (3b)**

Dark orange solid; yield: 73 %, m.p.: 109–111 °C, FT-IR (KBr): 3305 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.1 (d, J = 6.5 Hz, 2H, Ar–H), 7.24–7.67 (m, 6H, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 114.8, 116.1, 117.8, 126.4, 128.1, 129.3, 129.4, 132.3, 145.9, 146.2, and 149.3. Anal. For C\(_{17}\)H\(_{11}\)ClN\(_2\)S (260.45) Calcd.: C 59.90; H 3.45; N 10.75; S 12.29 %. Found: C 59.86; H 3.47; N 10.79; S 12.34 %.

**3-(4-nitrophenyl) benzo[d]thiazole-2(3H)-imine (3c)**

Brownish yellow solid; yield: 68 %, m.p.: 115–117 °C, FT-IR (KBr): 3306 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.05–8.05 (11H, m, Ar–H), 9.8 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 112.1, 121.7, 123.8, 125.3, 126.4, 126.9, 127.5, 127.9, 128.3, 128.6, 129.2, 131.5, 133.3, 133.8, 134.6, 166.7. 180.40. Anal. For C\(_{18}\)H\(_{13}\)NO\(_2\)S (271) Calcd.: C 57.56; H 3.32; N 15.50 %; Found: C 57.54; H 3.35; N 15.54 %; S 11.77 %.

**3-(naphthyl) benzo[d]thiazole-2(3H)-imine (3d)**

Brownish yellow solid; yield: 72 %, m.p.: 105–107 °C, FT-IR (KBr): 3305 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.05–7.67 (8H, m, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 29.7, 114.7, 115.7, 117.8, 119.4, 120.8, 124.7, 126.5, 128.3, 129.5, 130.3 and 133.2. Anal. For C\(_{18}\)H\(_{13}\)N\(_2\)S (240) Calcd.: C 73.91; H 4.35; N 10.14 %; S 11.59 %. Found: C 73.88; H 4.32; N 10.17; S 11.63 %.

**3-(p-toly) benzo[d]thiazole-2(3H)-imine (3e)**

Light brown solid; yield: 79 %, m.p.: 106–109 °C, FT-IR (KBr): 3304 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.05–7.67 (8H, m, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 29.7, 114.7, 117.8, 119.5, 122.3, 126.5, 127.7, 128.3, 130.1, 131.1, 133.2, 142.6. Anal. For C\(_{18}\)H\(_{13}\)NO\(_2\)S (240) Calcd.: C 51.15; H 2.95; N 9.18; S 10.49 %. Found: C 51.18; H 2.97; N 9.21; S 10.43 %.

**3-(2-bromophenyl) benzo[d]thiazole-2(3H)-imine (3f)**

Yellow solid; yield: 75 %, m.p.: 115–117 °C, FT-IR (KBr): 3306 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.03–7.67 (8H, m, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 114.7, 117.8, 119.5, 122.3, 126.5, 127.7, 128.3, 130.1, 131.1, 133.2, 142.6. Anal. For C\(_{18}\)H\(_{13}\)NO\(_2\)S (240) Calcd.: C 51.15; H 2.95; N 9.18; S 10.49 %. Found: C 51.18; H 2.97; N 9.21; S 10.43 %.

**3-(4-flurophenyl) benzo[d]thiazole-2(3H)-imine (3g)**

Dark yellow solid; yield: 70 %, m.p.: ≥ 180, FT-IR (KBr): 3306 (NH), 1595 (C=\(\text{N}_{\text{thiazole}}\)) cm\(^{-1}\). ¹H-NMR: 7.03–7.67 (8H, m, Ar–H), 10.1 (1H, s, N–H); ¹³C-NMR (6 ppm, CDCl\(_3\), 62.89 MHz): 114.8, 116.1, 117.8, 126.4, 128.01, 128.3, 129.4, 133.2, 145.9, 146.2, and 149.3. Anal. For C\(_{18}\)H\(_{13}\)FS (244) Calcd.: C 63.94; H 3.69; N 13.11 %. Found: C 63.91; H 3.67; N 11.51; S 13.07 %.

### RESULTS AND DISCUSSION

In the present study, we have reported a new successful methodology to be a convenient route for the synthesis of efficient 3-aryl benzo[d]thiazole-2(3H)-imine derivatives. For this purpose, thiourea derivatives were selected as essential substances to achieve target products. In the following, after diazotization of primary aromatic amines, diazonium salts were faced with purified thioureas in situ. This approach has resulted in the removal of N\(_2\) from
the reaction mixture. Subsequently, the cyclization reaction occurred by nitrogen attack leading to the removal of Br⁻. To conclude, all the desired final compounds were prepared under reflux conditions after the removal of the PhCOBr molecule. The TLC technique showed the formation of the desired products. Notably, the entire duration of the reaction, the mixture stirred vigorously and controlled temperature. A review of the authoritative literature shows that 3-aryl benz[d]thiazole-2(3H)-imine (3a–g) by this technique has not been reported previously.

The structures of all novel isolated products (3a–g) were confirmed by spectroscopic (FT-IR, 1H-NMR, 13C-NMR) data, and elemental analysis. The FT-IR spectra of the seven newly synthesized compounds showed a similar trend of stretching frequency modes. The FT-IR spectrum of the compound (3a) reveals the presence of stretching vibration for N–H bands at 3306 cm⁻¹. Furthermore, the sharp absorption peak in the region at 1595 cm⁻¹ indicates the presence of C=N imine stretching bands. The 1H-NMR spectra of the compound (3a) in CDCl₃ indicated multiple signals in the regions of δ 7.03–7.67 ppm due to the aromatic protons. Amino protons appear at δ 10.1 ppm. For the presence of C=N imine stretching bands. The furthermore the sharp absorption peak in the region υ 1595 cm⁻¹.

In summary, we have developed a functional, effective, and operationally simple convergent protocol to provide the benzothiazole with readily synth.

Conclusions

In summary, we have developed a functional, effective, and operationally simple convergent protocol to provide the benzothiazole with readily synthesized use of thioarene as a precursor. The present methodology reported the synthesis of a novel series of 3-aryl benz[d]thiazole-2(3H)-imines (3a–g), with simple workup and reasonable yield in the new route. Furthermore, the chemical composition of the benzothiazole derivatives was confirmed by spectroscopic results and elemental analysis.

REFERENCES