Synthesis and Characterization of Some Heterocyclic Compounds and Evaluation of Antibacterial Activity

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INTRODUCTION

Heterocyclic compounds are cyclic compounds in which the ring contains atoms other than carbon and hydrogen, i.e. some other elements, such as nitrogen, sulfur or oxygen, it is called the hetero-atom (Bahl and Bahl, 2008; Ivaez Builla and Barluenga, 2011). They show relative stability and aromaticity (Tewari and Vishnoi, 2017). The heteroatom types in the ring structure can categorize the heterocycles into oxygen, nitrogen or sulfur base. The compounds are subclassified also according to the ring structure size that in turn ascertain by whole atoms number. Its physiochemical properties correlate strongly with type and size of the ring structure as well as the substituent groups of the core scaffold (Martins et al., 2015). The heterocyclic compounds constitute a significant percent of the organic compounds and have an important role in biological and medical systems (Gupta, 2015). Triazine, triazole, oxadiazole and tetrazole are examples of heterocyclic compounds that implicated in this study.

Triazine
S-triazine or 1,3,5-triazine is a six-membered ring containing three carbons replaced by nitro-
gen joined by alternating single and double bonds (Smolin and Rapoport, 1959). It has a variety of industrial and biological applications in herbicides, polymer photostabilization and antitumor therapy (Sarmah et al., 2012). New s-triazine derivatives have also implicated as anti-AIDS, antituberculosis, and anticancerous (Baldaniya and Patel, 2009).

**Triazole**

Triazole has a five-membered ring structure containing two carbon and three nitrogen atoms and has molecular formula C$_2$H$_3$N$_3$ (Asif, 2017; Singh and Kandel, 2012). The 1H and 4H-1,2,4-triazole are tautomeric forms. They are pharmacologically important nuclei (Kaur et al., 2018; Banerjee et al., 2013). Triazole derivatives have a wide variety of pharmaceutical activity such as antifungal, antioxidant, antibacterial, anticonvulsant, antimalarial, anti-inflammatory, antiviral, anticancer, anti-tubercular, anti-nociceptive and other anticipated activities (Asif, 2017; Bharati et al., 2017; Demirbas et al., 2009).

**Oxadiazole**

Oxadiazole is a five-membered ring compound with an oxygen atom and two atoms of nitrogen and carbon (Sanchit, 2011; Mousa and Jassim, 2018). The general formula of this compound is C$_2$H$_2$ON$_2$. 1,3,4-Oxadiazole has its merit in pharmaceutical chemistry as substitutes for carboxylic acids, esters, and carboxamides (Ramazani et al., 2012; Holagh et al., 2012). It has an important implication in pesticide chemistry and polymer material. The derivative compounds exhibit range of biological activities such as analgesic (Dornelles et al., 2015), antibacterial, anticancer (Thirugnanasambanthan et al., 2012) and anti-inflammatory (Modi and Modi, 2012) and anticonvulsant activity (Bahjat, 2016).

**Tetrazole**

Tetrazole is a five-membered heterocyclic compound that its ring contains a carbon atom and four nitrogen atoms (Wei et al., 2015). The tetrazole moiety has a wide number of applications and its nitrogen-rich ring system is used in explosives, propellants and pharmaceuticals (Shanmugam et al., 2013). So, they have reported as anti-allergic and anti-asthmatic, anti-neoplastic, anti-inflammatory, antiviral and anticognitive disorder activities (Zamani et al., 2015).

**Aim of the study**

This study aims to synthesize new heterocyclic compounds derived from benzimidazole containing triazine, triazole, tetrazole and oxadiazole moiety and study the antibacterial activity for some selected prepared compounds.

**Experimental**

**General Synthesis Procedures**

**(A)** Synthesis of N-(1H-benzo[d]imidazole-2-yl)formamide (Petrova et al., 2015)

A 2-aminobenzimidazole (0.5 g, 0.003 mol) and formic acid was refluxed in water bath for 13 hours. TLC was used to monitor the reaction course. Then, formic acid excess was evaporated and recrystallized the product from appropriate solvent to get a beige product, (0.47 g, 79%). IR: 1610, 1327, 1566, 1681, 3045, 2824, 3256 cm$^{-1}$. Scheme 1 shows the reaction.

**Scheme 1: Synthesis of the compound (A)**

**(B)** Synthesis of (E)-N-(1H-benzo[d]imidazol-2-yl)-N-phenylformophydrazonamide (Arulmurugan et al., 2010)

A (0.3 g, 0.001 mol) of the compound (A) was dissolved in 20 ml of ethanol. Amount (0.18 g, 0.001 mol) of phenylhydrazine was added and stirring in a
Table 1: Physical properties for prepared compounds

<table>
<thead>
<tr>
<th>Compound</th>
<th>M. Formula</th>
<th>M. weight</th>
<th>Color</th>
<th>Melting point °C</th>
<th>Yield</th>
<th>Rf</th>
<th>Solvent</th>
<th>TLC</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>C₈H₇N₃O</td>
<td>161.16</td>
<td>Beige</td>
<td>190-192</td>
<td>79%</td>
<td>0.58</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>C₁₄H₁₃N₅</td>
<td>251.29</td>
<td>Light brown</td>
<td>Gum</td>
<td>85%</td>
<td>0.53</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>C₁₈H₁₉N₅O₂</td>
<td>337.38</td>
<td>Light brown</td>
<td>193-195</td>
<td>85%</td>
<td>0.57</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>C₁₆H₁₄N₆O</td>
<td>306.33</td>
<td>Deep brown</td>
<td>107-109</td>
<td>84%</td>
<td>0.69</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>C₁₆H₁₃N₅O</td>
<td>291.31</td>
<td>Golden beige</td>
<td>212-214</td>
<td>80%</td>
<td>0.72</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>F</td>
<td>C₁₆H₁₆N₄</td>
<td>264.33</td>
<td>Light yellow</td>
<td>201-203</td>
<td>78%</td>
<td>0.65</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>G</td>
<td>C₁₉H₁₈N₄</td>
<td>302.38</td>
<td>Gum</td>
<td>82%</td>
<td>0.74</td>
<td></td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>C₂₅H₂₂N₈O₂</td>
<td>466.51</td>
<td>Gum</td>
<td>85%</td>
<td>0.67</td>
<td></td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>C₁₄H₁₀ClN₃</td>
<td>255.71</td>
<td>Light yellow</td>
<td>212-214</td>
<td>77%</td>
<td>0.54</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>J</td>
<td>C₁₈H₁₆ClN₅O₂</td>
<td>341.80</td>
<td>Light brown</td>
<td>112-114</td>
<td>73%</td>
<td>0.63</td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>C₁₈H₁₄ClN₅O</td>
<td>327.77</td>
<td>Black</td>
<td>71%</td>
<td>0.56</td>
<td></td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>L</td>
<td>C₂₃H₁₆ClN₅O</td>
<td>413.87</td>
<td>Orange</td>
<td>76%</td>
<td>0.72</td>
<td></td>
<td>Benzene: EtOH 1:2</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>C₁₄H₁₁ClN₆</td>
<td>298.73</td>
<td>Orange</td>
<td>70%</td>
<td>0.76</td>
<td></td>
<td>Benzene: MetOH 1:2</td>
<td></td>
</tr>
</tbody>
</table>


Table 2: Estimated inhibition zones for three synthetized derivatives compounds against Escherichia coli and Staphylococcus aureus.

<table>
<thead>
<tr>
<th>Derivative Compound</th>
<th>Escherichia coli</th>
<th>Staphylococcus aureus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Conc. (mg/ml) M ± SE (mm) R = 3</td>
<td>Conc. (mg/ml) M ± SE (mm) R = 3</td>
</tr>
<tr>
<td>L</td>
<td>25 12.333 ± 1.4530 25 12.333 ± 0.33333</td>
<td></td>
</tr>
<tr>
<td></td>
<td>50 14.667 ± 0.33333 50 13.667 ± 0.66667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75 17.333 ± 0.33333 75 19.333 ± 0.66667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 17.000 ± 0.57735 25 17.000 ± 0.88192</td>
<td></td>
</tr>
<tr>
<td>M</td>
<td>25 16.667 ± 0.88192 25 20.667 ± 0.66667</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75 25.333 ± 0.88192 75 20.000 ± 1.1547</td>
<td></td>
</tr>
<tr>
<td></td>
<td>25 13.333 ± 0.66667 25 13.333 ± 0.88192</td>
<td></td>
</tr>
<tr>
<td></td>
<td>75 23.667 ± 0.66667 75 20.000 ± 1.1547</td>
<td></td>
</tr>
</tbody>
</table>

Conc.: Concentration; R: Numbers of replicates; M: Mean of inhibition zone diameter (mm); SE: Standard error of the mean.
L= derivative compound 1-((4-chlorophenyl)-N-((5-phenyl-1,3,4-oxadiazol-2-yl)methyl)-1H-benzo[d]imidazol-2-yl)methanimine
M= derivative compound 2-((5-(4-chlorophenyl)-4,5-dihydro-1H-tetrazol-1-yl)-1H-benzo[d]imidazole
D= derivative compound 4-((1H-benzo[d]imidazol-2-yl)amino-1-phenyl-1,6-dihydro-1,2,4-triazine-5(4H)-one

Scheme 4: Synthesis of the compound (D)
Scheme 5: Synthesis of the compound (E)
Figure 1: Antibacterial activity test against two species of bacteria on Muller-Hinton agar surface for three prepared compounds. (A) against *Escherichia coli*. (B) against *Staphylococcus aureus*.

Scheme 6: Synthesis of the compound (F)

Scheme 7: Synthesis of the compound (G)

Scheme 8: Synthesis of the compound (H)

Scheme 9: Synthesis of the compound (I)

water bath for 48 hours at 67°C. TLC traced the reaction and the solvent had evaporated slowly to form a gum product, (0.39 g, 85%). IR: 1660, 1170, 1595, 1259, 3043, 3325 cm⁻¹, as shown in Scheme 2.
Scheme 10: Synthesis of the compound (J)

Scheme 11: Synthesis of the compound (K)

Scheme 12: Synthesis of the compound (L)

Scheme 13: Synthesis of the compound (M)

Scheme 14: Mechanism of synthesis compound (A)

Scheme 15: Mechanism of synthesis compound (F)

Scheme 16: Mechanism of synthesis compound (H)

Scheme 17: Mechanism of synthesis compound (K)
(C) General procedure of synthesis of ethyl(E) –N-(((1H-benzo[d]imidazol-2-yl)amino)methylene) amino-N-phenylglycinate (Sayed et al., 2018)

A (0.3 g, 0.001 mol) of the compound (B) was dissolved in 15 ml of ethanol with some drops of triethylamine. Then, (0.14 g, 0.001 mol) ethyl chloroacetate was added, stirring in a water bath at 67°C for 2 hours and TLC monitored the progression. The compound was purified by recrystallization from ethanol, light brown crystals were obtained, (0.34 g, 85%). IR: 1592, 1035, 1487, 1742, 2971, 1306, 1182 cm⁻¹, as shown in Scheme 3.

(D) Synthesis of 4-(((1H-benzo[d]imidazol-2-yl)amino)-1-phenyl-1,6-dihydro-1,2,4-triazine-5(4H)-one (Dolzhenko, 2011)

A mixture of (0.3 g, 0.0008 mol) of the compound (C) and few KOH drops solution in ethanol 10% in solvent ethanol was stirred for 10 minutes at room temperature. Then, it was subjected to reflux for 45 hours. The TLC told there was no starting materials left, the solvent was allowed to evaporate slowly to get a brown product, (0.22 g, 84%). IR: 1493, 1378, 1551, 1731, 2977, 1196 cm⁻¹, as shown in Scheme 4.

(E) Synthesis of 4-(((1H-benzo[d]imidazol-2-yl)-1-phenyl-4,5-dihydro-1,2,4-triazine-6(1H)-one (Soleiman, 2016)

A (0.3 g, 0.001 mol) of the compound (B) was dissolved in ethanol with some drops triethylamine and stirred more than 5 minutes. Then, (0.13 g, 0.001 mol) of chloro acetyl chloride was added slowly to the reaction solution and stirred in an ice bath during addition. The stirring in a water bath was at 67°C for 3 hours. TLC followed the progress, and the compound was purified by recrystallization from ethanol to get a golden beige crystals, (0.27 g, 80%), as shown in Scheme 5.

(F) Synthesis of 4-(((1H-benzo[d]imidazol-2-yl)mino)methyl)-N,N-dimethylaniline (Arulmurugan et al., 2010)

2-aminobenzimidazole (0.28 g, 0.002 mol) was dissolved in ethanol with some drops glacial acetic acid. Then, (0.3 g, 0.002 mol) of 4-dimethylaminobenzaldehyde added slowly to the solution, stirring in a water bath at 67°C for more than 7 hours. The reaction progress monitoring accomplished by TLC. The product was dried to form a light yellow powder; (0.43 g, 78%). IR: 1676, 1164, 1594, 2976, 3074 cm⁻¹, as shown in Scheme 6.

(G) Synthesis of N,N-dimethyl-4-(((1-((prop-2-yn-1-yl)-1H-benzo[d]imidazol-2-yl)limino)methyl) aniline (Akeroyd, 2010)

The compound (F) (1 g, 0.003 mol) was dissolved in (20 ml) of 1,4-dioxan with some drops of triethylamine. Then, (0.4 g, 0.003 mol) of propargyl bromide was added to the resulting solution with stirring for 15 minutes. This mixture was refluxed for 28 hours. TLC monitored the reaction and the product was dried to get a dark red product, (0.93 g, 82%). IR: 1638, 1216, 1466, 2085, 2984, 3377 cm⁻¹, as shown in Scheme 7.

(H) Synthesis of N,N-dimethyl-4-(((1-(4-nitrophenyl)-1H-1,2,3-triazol-4-yl)methyl)-1H-benzo[d]imidazol-2-yl)imino)methyl)aniline (Akeroyd, 2010; Becer et al., 2009)

A (0.5 g, 0.001 mol) of compound (G) dissolved in N, N-Dimethyl formamide (DMF). DMF (5 ml) was added to (0.3 g, 0.002 mol) sodium ascorbate suspension and CuSO₄. H₂O (0.2 gm, 0.001 mol) with DMF (4 ml). Then, stirred the resulting mixture for 10 minutes and added (0.2 g, 0.001 mol) 4-nitrophenyl azide. Then, refluxed for 34 hours and monitored the reaction by using TLC. The product was dried to get a dark red product, (0.65 g, 85%). IR: 1658, 1090, 1443, 1496, 2929, 1253, 1312 cm⁻¹, as shown in Scheme 8.

(I) Synthesis of N-(1H-benzo[d]imidazol-2-yl)-1-(4-chlorophenyl) methanimine (Arulmurugan et al., 2010)

A (0.35 g, 0.0007 mol) of 2-aminobenzimidazole was dissolved in ethanol with some drops of glacial acetic acid. Then, (0.1 g, 0.0007 mol) 4-chlorobenzaldehyde was added slowly to the reaction solution, stirring in a water bath at 67°C for more than 13 hours. TLC used to follow the reaction progress. The product was dried to obtain a light yellow powder; (0.51 g, 77%). IR: 1670, 1063, 1562, 733, 2981, 3056 cm⁻¹, as shown in Scheme 9.

(J) Synthesis of ethyl 2-((2-(4-chlorobenzylidene)amino)-1H-benzo[d]imidazol-1-yl)acetate (Sayed et al., 2018)

The compound (I) (0.5 g, 0.001 mol) was dissolved in ethanol with some drops of triethylamine and stirred for 5 minutes. Then, (0.2 g, 0.001 mol) of ethyl chloroacetate was added slowly to the reaction solution, stirring in a water bath at 67°C for more than 9 hours. The progression followed by TLC. The product was dried to obtain a light brown powder; (0.48 g, 73%). IR: 1672, 1379, 1473, 1742, 2978, 739, 1379 cm⁻¹, as shown in Scheme 10.

(K) Synthesis of 2-(2-(4-chlorobenzylidene)amino)-1H-benzo[d]imidazol-1-yl) acetoxydrazide (Sayed et al., 2018)

A mixture of (0.18 g, 0.0005 mol) from the com-
Compound (J) and hydrazine was stirred 15 minutes at room temperature and refluxed for 17 hours. TLC was used to follow the reaction progress. The product was dried to obtain a black powder, (0.12 g, 71%). IR: 1610, 1104, 1489, 1675, 733, 3030, 2938, 3100, 3249 cm⁻¹, as shown in Scheme 11.

*(L)* Synthesis of 1-(4-chlorophenyl)-N-{1-{5-phenyl-1, 3, 4-oxadiazol-2-yl} methyl}-1H-benzo[d]imidazol-2-yl) methanimine (Hameed and Akhtar, 2011)

A (0.18 g, 0.0005 mol) of the compound (K) was dissolved with (0.06 g, 0.0005 mol) benzoic acid using 10 ml of POCl₃ as a solvent. This mixture gently refluxed for 36 hours. Then, crushed ice was added slowly. The mixture was mixed slowly with continuous stirring. The acid mixture was mixed with potassium carbonate. TLC was used to follow the reaction progress. Then, it was left for the next day to settle down, collected the precipitate by filtration and washed with distilled water (50 ml). The product was dried to get a beige powder, (0.13 g, 70%), as shown in Scheme 12.

IR: 1678, 1280, 1549, 1610, 1104, 1489, 1675, 733, 3030, 2938, 1219, and 1182 cm⁻¹. The compound was identified using FTIR spectroscopy by appearance of (C–O) stretching vibration of amides at (1173) cm⁻¹ and appearance of (C–N) stretching vibration at (1629) cm⁻¹, also appearance of (C–N) stretching vibration at (1610) cm⁻¹, appearance of (C–N) stretching vibration at (1327) cm⁻¹, appearance of (C=O) stretching vibration at (1666) cm⁻¹, appearance of (C–H) aromatic at (3045) cm⁻¹, appearance of (C=O) aldehyde at (2824) cm⁻¹, and evanescence of (NH₂) stretching vibration at 3368 cm⁻¹. The proposed mechanism is shown in Scheme 14. (Clayden *et al.*, 2012)

*(M)* Synthesis of 2-{5-(4-chlorophenyl)-4,5-dihydro-1H-tetrazol-1-yl)-1H-benzo[d]imidazole

A (0.17 g, 0.0006 mol) of the compound (I) was dissolved in THF. Then, (0.039 g, 0.0006 mol) of sodium azide was added to this solution, stirring in a water bath at 67°C for more than 10 hours. The progress was followed by usage of TLC. The product was dried to obtain an orange powder, (0.13 g, 70%), as shown in Scheme 13. Table 1 delineates the physical properties for these compounds.

**Antibacterial activity assay**

Biologically, the antibacterial activity for three selected synthesized derivatives, viz. compounds L, M and D, were evaluated using two aerobic bacteria that isolated from infected burn wounds: *Staphylococcus aureus* (S. aureus) and *Escherichia coli* (E. coli) as an example for Gram-positive and -negative bacteria respectively. Agar well diffusion method (Aljanaby, 2018) was applied to assess that activity. The synthesized derivative compounds dissolved in Dimethyl Sulphoxide (DMSO) to prepare three samples (25, 50 and 75 mg/ml) from each. Then, four wells have made in Muller-Hinton Agar by sterile (5mm) borer. Suspension of the tested bacteria (1x10⁶ CFU/ml) was spread on media plates by sterile cotton swabs. 100 µl from each concentration was transferred to each well and left at the room temperature for 15 minutes to allow the compound to spread into the agar and incubated at 37°C for 24 hours. The tests were conducted in triplicate. The diameters of inhibition zones that arose out were measured in millimeters (mm).

**Statistical analysis**

IBM SPSS statistics, version 8 for windows, was the statistical software that have been used for the analysis to make comparisons between inhibition zones diameters (mm). T-test had implicated and P-value < 0.05 was considered to be statistically significance.

**RESULTS AND DISCUSSION**

**Characterization of prepared compounds**

*(A)* Characterization of N-(1H-benzo[d]imidazol-2-yl)formamide

The compound was identified using FTIR spectroscopy by appearance of (C=O) stretching vibration of amides at (1681) cm⁻¹ and appearance of (NH) stretching vibration for amide at (3256) cm⁻¹, also appearance of (C=O) stretching vibration at (1610) cm⁻¹, appearance of (C–N) stretching vibration at (1327) cm⁻¹, appearance of (C=O) stretching vibration at (1666) cm⁻¹, appearance of (C=O) aromatic at (3045) cm⁻¹, appearance of (C=O) aldehyde at (2824) cm⁻¹, and evanescence of (NH₂) stretching vibration at 3368 cm⁻¹. The proposed mechanism is shown in Scheme 14. (Clayden *et al.*, 2012)

*(B)* Characterization of (E) -N-(1H-benzo[d]imidazol-2-yl)-N-phenyl formy morphazonamide

The compound was identified using FTIR spectroscopy by appearance of (N = C) stretching vibration at (1660) cm⁻¹, also appearance of (C–N) stretching vibration at (1170) cm⁻¹, appearance of (C–C) stretching vibration at (1595) cm⁻¹, appearance of (C=H) stretching vibration at (1681) cm⁻¹.

*(C)* Characterization of ethyl(E) -N-(((1H benzo[d]imidazol-2-yl)amino)methylene)amino-N-phenylglycinate

The FTIR spectroscopy identified this compound by appearance of (C=O) stretching vibration of ester at (1742) cm⁻¹. The spectrum also showed a band at (1182) cm⁻¹ due to (C=O) stretching vibration for (OET) group, band (C=H) stretching vibration aliphatic of ethyl group appeared at (2971) cm⁻¹.
appearance of (C=N) stretching vibration at (1592) cm\(^{-1}\), appearance of (C-N) stretching vibration at (1035) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1487) cm\(^{-1}\) and evanesence of (N-H) stretching vibration at (3325) cm\(^{-1}\).

**D** Characterization of 4-(((1H-benzo[d]imidazol-2-yl)amino-1-phenyl-1,6-dihydro-1,2,4-triazine-5(4H)-one

It was identified by using FTIR spectroscopy by appearance of (C=O) stretching vibration of amide at (1731) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1493) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1378) cm\(^{-1}\), appearance of (C=C) stretching vibration of amide at (1551) cm\(^{-1}\), appearance of (C-H) stretching vibration aromatic at (2977) cm\(^{-1}\), appearance of (N-N) stretching vibration at (1196) cm\(^{-1}\) and disappearance of (N-H) stretching vibration at (3206) cm\(^{-1}\).

**E** Characterization of 4-((1H-benzo[d]imidazol-2-yl)-1-phenyl-4,5-dihydro-1,2,4-triazine-5(4H)-one

This compound was identified by using FTIR spectroscopy by appearance of (C=O) stretching vibration of amide at (1683) cm\(^{-1}\), also appearance of (C=N) stretching vibration of at (1590) cm\(^{-1}\), appearance of (C-H) stretching vibration at (3100) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1238) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1537) cm\(^{-1}\), appearance of (N-N) stretching vibration at (1447) cm\(^{-1}\) and disappearance of (N-H) stretching vibration at (3325) cm\(^{-1}\). The \(^1\)H-NMR of compound (E) showed (7.02, 7.30) ppm for aromatic of the phenyl group, (8.31) ppm for (CH) of triazine ring, (3.07) ppm for (CH\(_2\)) of triazine ring and (10.31) ppm for (N-H) of the imidazole ring. The \(^1\)C-NMR appearance of (121.84, 114.94, 129.38) ppm for aromatic of the phenyl ring, (146.08) ppm for (C=O) of triazine ring and (45.77) ppm for (CH\(_2\)) of triazine ring.

**F** Characterization of 4-(((1H-benzo[d]imidazol-2-yl)iminoo)-N,N-dimethylaniline

This compound was identified using FTIR spectroscopy by presence of (N=CH) stretching vibration at (1676) cm\(^{-1}\), also appearance of (C-N) stretching vibration at (1164) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1594) cm\(^{-1}\), appearance of (C-H) stretching vibration aliphatic at (2976) cm\(^{-1}\), appearance of (N-H) stretching vibration at (3074) cm\(^{-1}\), and disappearance of (NH\(_2\)) stretching vibration of at (3367) cm\(^{-1}\). The Scheme 15 shows the suggested mechanism. (Clayden et al., 2012)

**G** Characterization of N,N-dimethyl-4-(((1-prop-2-yn-1-yl)-1H-benzo[d]imidazol-2-yl)imino)methyl)aniline

This compound was identified by using FTIR spectroscopy and by presence of (C≡C) stretching vibration at( 2085) cm\(^{-1}\), also appearance of (C=N) stretching vibration at (1638) cm\(^{-1}\), appearance of (C-N) stretching vibration at(1216) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1466) cm\(^{-1}\), appearance of (C-H) stretching vibration aliphatic at (2984) cm\(^{-1}\), and appearance of an absorption band at (3377) cm\(^{-1}\) due to (C-H) stretching vibration of the acetylene group and evanesence of (N-H) at (3074) cm\(^{-1}\).

**H** Characterization of N,N-dimethyl-4-(((1-((1-(4-nitrophenyl)-1H-1,2,3-triazol-4-yl)methyl)-1H-benzo[d]imidazol-2-yl)imino)methyl)aniline

The compound was identified using FTIR spectroscopy by appearance of (N= N) stretching vibration at (1496) cm\(^{-1}\). The spectrum also showed a band at (1253) cm\(^{-1}\) due to (N-N) stretching vibration for triazole ring, another band for aromatic (NO\(_2\)) appeared at (1312) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1658) cm\(^{-1}\), appearance of (C=N) stretching vibration at( 1090) cm\(^{-1}\), appearance of (C=C) stretching vibration at( 1443) cm\(^{-1}\), appearance of (C-H) stretching vibration aliphatic at (2929) cm\(^{-1}\) and disappearance of (C≡C) at (2085) cm\(^{-1}\). Also, disappearance of (C-H) for the acetylene group at (3377) cm\(^{-1}\). Clayden (Clayden et al., 2012) suggested the following mechanism for this mechanism, Scheme 16.

**I** Characterization of N-((1H-benzo[d]imidazol-2-yl)-1-(4-chlorophenyl) methanimine

It was identified by using FTIR spectroscopy with appearing (N=CH) stretching vibration at (1670) cm\(^{-1}\). The spectrum also showed an absorption band at (733) cm\(^{-1}\) refer to (C-Cl) band, appearance of (C=N) stretching vibration at(1063) cm\(^{-1}\), appearance of (C=C) stretching vibration at(1562) cm\(^{-1}\), appearance of (C-H) stretching vibration aliphatic at(2981) cm\(^{-1}\) and disappearance of (NH\(_2\)) at (3367) cm\(^{-1}\).

**J** Characterization of ethyl 2-((4-chlorobenzylidene)amino)-1H-benzo[d]imidazol-1-yl)acetate

The compound was identified by using FTIR spectroscopy with appearing (C=O) stretching vibration of ester at (1742) cm\(^{-1}\) and appearance of (C-O) stretching vibration for (OEt) group at (1379) cm\(^{-1}\), appearance of (C=N) stretching vibration at(1672) cm\(^{-1}\), appearance of (C-N) stretching vibration at(1379) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1473) cm\(^{-1}\), appearance of (C-H) stretching vibration aliphatic at (2978) cm\(^{-1}\), appearance
of (C–Cl) stretching vibration at (739) cm\(^{-1}\) and evanescence of (N–H) at (3056) cm\(^{-1}\).

**(K)** Characterization of 2-(2-((4-chlorobenzylidene)amino)-1H-benzo[d]imidazole-1-yl)acetohydrazide

The compound was identified by using FTIR spectroscopy with appearing (C=O) stretching vibration of amide at 1675 cm\(^{-1}\) and (NH\(_2\)) symmetric and asymmetric stretching vibration at (3249-3136) cm\(^{-1}\). The spectrum also showed bands at (2938, 3030) cm\(^{-1}\) due to (C–H) stretching vibration for aliphatic and aromatic groups respectively; another bands for (C–Cl) appeared at (733) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1610) cm\(^{-1}\), appearance of (C=N) stretching vibration at (1104) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1489) cm\(^{-1}\) and disappearance of (C=O) stretching vibration of ester at (1742) cm\(^{-1}\). Scheme 17 delineates the likely suggested mechanism (Clayden et al., 2012)

**(L)** Characterization of 1-(4-chlorophenyl)-N-(1-((5-phenyl-1,3,4-oxadiazol-2-yl)methyl)-1H-benzo[d]imidazol-2-yl)methanimine

This compound was identified using FTIR spectroscopy by appearance of (N-N) at (1414) cm\(^{-1}\), the spectrum also showed a band at (1678) cm\(^{-1}\) due to (N–N) stretching vibration. Another band for (C–O) stretching vibration ether at (1173) cm\(^{-1}\) and appearance of (C–H) stretching vibration for aromatic ring at (3061) cm\(^{-1}\), appearance of (C–N) stretching vibration at (1280) cm\(^{-1}\), appearance of (C=C) stretching vibration at (1549) cm\(^{-1}\) and disappearance of (C=O) stretching vibration of amide at (1675) cm\(^{-1}\). The \(^{1}H\)-NMR of compound (O) showed (7.95, 7.66) ppm for aromatic of 4-chlorophenyl group, (7.51) ppm for aromatic of phenyl group attached with oxadiazole ring and (8.16, 8.15) ppm for phenyl group. \(^{13}C\)-NMR appearance of (167.77) ppm for aromatic of (N-C=N), (167.67) ppm for (N=C) of Schiff base, (164.52) ppm for (O-C=N) and (123.83) ppm for phenyl ring.

**(M)** Characterization of 2-(5-(4-chlorophenyl)-4,5-dihydro-1H-tetrazol-1-yl)-1H-benzo[d]imidazole

The compound was identified using FTIR spectroscopy by appearance of (N=N) stretching vibration at (1565) cm\(^{-1}\), the spectrum also showed a band at (1409) cm\(^{-1}\) due to (N–N) stretching vibration, another band of (N–H) stretching vibration for amine group appeared at (3230) cm\(^{-1}\) and emergence of (C–H) stretching vibration for aromatic ring at (3057) cm\(^{-1}\). Also, appearance of absorption band at (734) cm\(^{-1}\) refer to (C–Cl) band and disappearance of (N=C) stretching vibration of Schiff base at (1670) cm\(^{-1}\). The compound (M) is also identified by \(^{1}H\)-NMR appearance of (7.51, 7.67) ppm for phenyl group, (7.92, 7.95) ppm for 4-chlorophenyl group. \(^{13}C\)-NMR appearance of (167.77) ppm for aromatic of (N-C=N), (129.91, 129.72) ppm for 4-chlorophenyl group and (133.33, 132.55) ppm for phenyl ring.

**Antibacterial activity**

The estimated antibacterial activity for derivative compounds (L, M and D), based on diameters of its own inhibition zones, gives "good" effect against pathogenic bacteria with significant inhibition zone appeared at every concentration (25, 50 and 75 mg/ml), (Table 2 and Figure 1). The (M) compound gives "excellent" effect against E. coli at concentrations of 50 and 75 mg/ml, inhibition zone diameters 21.667 ± 0.88192 and 25.333 ± 0.33333 mm respectively; however, the inhibition zone diameters are 20.667 ± 0.66667 and 25.000 ± 0.57735 respectively against S. aureus (Aljanaby, 2018).

L, M and D denote the three derivative compounds: derivative compound 1-(4-chlorophenyl)-N-(1-((5-phenyl-1,3,4-oxadiazol-2-yl)methyl)-1H-benzo[d]imidazol-2-yl)methanimine, derivative compound 2-(5-(4-chlorophenyl)-4,5-dihydro-1H-tetrazol-1-yl)-1H-benzo[d]imidazole and derivative compound 4-((1H-benzo[d]imidazol-2-yl)amino-1-phenyl-1,6-dihydro-1,2,4-triazine-5(4H)-one respectively.

**CONCLUSIONS**

Heterocyclic amine derivatives can be used as reagents for elements. The 2-aminobenzimidazole can be used as a launching material to synthesize number of compounds (Triazone, Oxadiazole, Triazole and Tetrazole). Synthesizing of Triazone, Oxadiazole, Triazone, Tetrazole via cyclization of the Schiff base derivatives with ethyl chloroacetate and chloro acetyl chloride, benzoic acid, 4-nitrophenyl azide, sodium azide and phenyl azide are possible respectively. The FT-IR, \(^{13}C\)-NMR and \(^{1}H\)-NMR spectra data give good evidence for the formation of the compounds that have been prepared. Some of prepared compounds exhibit antibacterial agents.

**Conflict of interest**

The authors declare that they have no conflict of interest for this study.

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