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Synthesis, Characterization and Antibacterial Screening of Some Novel Compounds containing Multi N-Fused Heterocycles

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An attempt has been made to synthesize novel multi N-fused heterocyclic compounds containing four divergent heterocyclic compounds such as imidazole, pyrimidine, morpholine and indole. A series of *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamide (**6a-c**) was accomplished in good yields with 1-(1*H*-benzo-[*d*]imidazol-2-yl)ethanone (**1**) as starting compound and through the formation of (*E*)-1-(1*H*-benzo[*d*]imidazol-2-yl)-3-phenylprop-2-ne-1-ones (**2a-c**), 4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-amines (**3a-c**) and *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyr-imidin-2-yl)-2-chloroacetamides (**4a-c**) as intermediates on extension of the reaction. The structural elucidation of all the synthesized compounds were characterized by IR, ^{1}H NMR, mass spectral data and elemental analysis. Further, the title compounds were also used to evaluate their antibacterial activity.

Keywords: Pyrimidine derivatives, Fused heterocyclic compounds, Antibacterial activity.

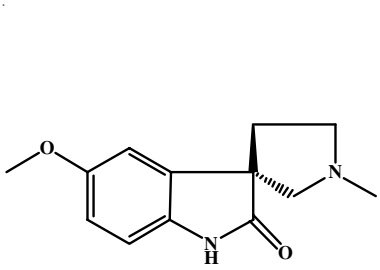
INTRODUCTION

The nitrogen containing heterocyclics are widely distributed in numerous natural and medicinal products [1]. A wide number of these heterocyclic derivatives disclosed significant pharmacological activities such as anticancer [2], antifungal [3] and antiviral [4]. Pyrimidine ring has been emerged an attractive tool for researcher in medicinal chemistry [5] because of its intrinsic pharmacological activities such as *Mycobacterium tuberculosis* [6], antioxidants [7], antidiabetics [8], antiallergic [9], antioxidant [10], antiviral [11], antihistaminic [12], cytostatic, immunomodulating [13], herbicidal [14], anticonvulsant [15], fungicidal [16], antitoxoplasma [17], antimalarial [18], antibacterial1 [19], antifilerial [20] antileishmanial [21] and anticancer activities [22].

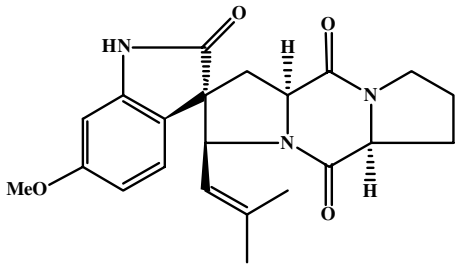
Pyrimido[1,2-*a*]benzimidazoles have been recognized for their pharmacological interest and and have been characterized by remarkable pharmacological efficacy such as antidepressant [23], antidiuretic [24], antihypertensive [25], macrofilaricidal [26], antiviral [27], antibacterial [28], antiseptic [29], antimicrobial, antiarrythmic [30], herbicidal [31], anticancer [32] and anti-glycation [33]. *N*-Fused heterocycles are the prime class of organic compounds that have gained remarkable consciousness over the past period [34]. Pyridine-pyrimidine fused derivatives are precious derivatives owing to their different biological and pharmaceutical activities. They have exhibited antitumour [35], anti-inflammatory [36], antibacterial [37], antifungal [38], antihypertensive [39], diuretic [40] and anti-HIV [41] activities. Among the different heterocyclic systems, the indole ring carries an eminent role in organic chemistry due to its presence as a core unit in a number of compounds exhibiting a wide spectrum of biological activities [42,43]. It is a prime framework as a structural motif in biologically related compounds as natural products and pharmaceuticals [44] such as horsfiline **(I)**, spirotryprostatin A & B **(II, III)**, elacomine **(IV)** and alstonisine **(V)**.

EXPERIMENTAL

The chemicals and solvents were procured from Merck, and Aldrich Chemicals and used without further purification.



Horsfiline (I)



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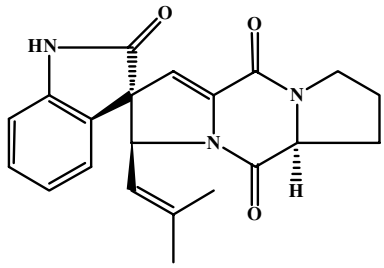
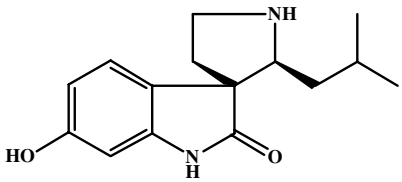
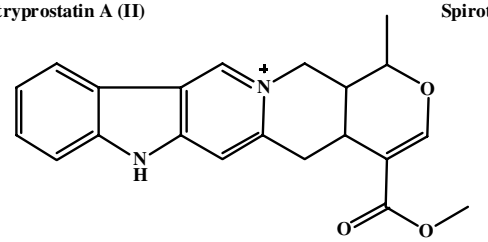


Spirotryprostatin B (III)



Elacomine (IV)



Alstonisine (V)

The synthesized compounds were identified by comparing their physical constants, IR and NMR spectra. The use of thin-layer chromatography (TLC) on silica gel polygram SILG/ UV 254 plates was employed to check the purity as well as the progress of the reactions.

Synthesis of (*E*)-1-(1*H*-benzo[*d*]imidazol-2-yl)-3-phenylprop-2-ne-1-one (2a): To a stirred mixture of 1-(1*H*-benzo[*d*]-imidazol-2-yl)ethanone **(1)** (0.01 mol) and an aromatic aldehyde (0.01 mol) in methanol (15 mL) was added sodium methoxide (0.54 g) and then the solution was stirred at room temperature for 20-22 h. The resulting solution was poured into ice-cold water and the deposited solid was filtered, dried and recrystallized from ethylacetate to obtain (*E*)-1-(1*H*-benzo[*d*]imidazol-2-yl)-3-phenylprop-2-ne-1-ones (**2a-c**).

(*E*)-1-(1*H*-Benzo[*d*]imidazol-2-yl)-3-phenylprop-2-ne-1-one (2a): Colour: brown; yield: 76%; m.p.: 118 ºC; IR (KBr, ν_{max}, cm^{-1}): 3180 (N-H), 3066 (C-H, Ar), 1748 (C=O), 1638 (C=N), 1584 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.77-7.27 (m, 9H, Ar), 5.26 (d, 1H, *J* = 14.8 Hz, =CH), 4.55 (d, 1H, *J* = 14.8 Hz, =CH), 3.82 (s, 1H, NH); MS (*m/z*, M^+): 248; Elemental analysis of $C_{16}H_{12}N_2O$: calcd. (found) %: C, 77.36 (77.40); H, 4.87 (4.87); N, 11.27 (11.28); O, 6.44 (6.44).

(*E*)-1-(1*H*-Benzo[*d*]imidazol-2-yl)-3-(2-bromophenyl)-prop-2-ne-1-one (2b): Colour: pale yellow; yield: 81%; m.p.: 133 ºC; IR (KBr, ν_{max}, cm^{-1}): 3165 (N-H), 3052 (C-H, Ar), 1742 (C=O), 1647 (C=N), 1588 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.71-7.31 (m, 8H, Ar), 5.21 (d, 1H, *J* = 15.2 Hz, =CH), 4.61 (d, 1H, *J* = 15.2 Hz, =CH), 3.87 (s, 1H, NH); MS (*m/z*, M^+): 326; Elemental analysis of $C_{16}H_{11}BrN_2O$: calcd. (found) %: C, 58.70 (58.74); H, 3.39 (3.39); Br, 24.41 (24.42); N, 8.56 (8.56); O, 4.89 (4.89).

(*E*)-1-(1*H*-Benzo[*d*]imidazol-2-yl)-3-(2-nitrophenyl)-prop-2-ne-1-one (2c): Colour: yellow; yield: 74%; m.p.: 125 ºC; IR (KBr, ν_{max}, cm^{-1}): 3171 (N-H), 3058 (C-H, Ar), 1745 (C=O), 1655 (C=N), 1578 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.75-7.30 (m, 8H, Ar), 5.25 (d, 1H, *J* = 14.6 Hz, =CH), 4.66 (d, 1H, *J* = 14.6 Hz, =CH), 3.82 (s, 1H, NH); MS (*m/z*, M^+): 293; Elemental analysis of $C_{16}H_{11}N_3O_3$: calcd. (found) %: C, 65.49 (65.53); H, 3.78 (3.78); N, 14.33 (14.32); O, 16.36 (16.37).

Synthesis of 4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenyl-pyrimidin-2-amines (3a-c): A solution consisting of compound **2a-c** (0.01 mol), guanidine nitrate (0.01 mol) and sodium methoxide (25%, 15 g) in methanol (20 mL) was refluxed on water bath for 6-8 h with uniform stirring then cooled. The obtained precipitate was filtered, washed thoroughly with ethanol and then recrystallized from ethylacetate to obtain pure **3a-c**.

4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-amine (3a): Colour: yellow; yield: 77%; m.p.: 141 ºC; IR (KBr, ν_{max}, cm^{-1}): 3262 (NH_2), 3138 (N-H), 3058 (C-H, Ar), 1644 (C=N), 1574 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.69-7.25 (m, 8H, Ar), 7.21 (s, 1H, =CH), 4.74 (s, 2H, NH_2); MS (*m/z*, M^+): 287; Elemental analysis of $C_{17}H_{13}N_5$: calcd. (found) %: C, 71.00 (71.06); H, 4.56 (4.56); N, 24.35 (24.37).

4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-(2-bromophenyl)-pyrimidin-2-amine (3b): Colour: pale yellow; yield: 71%; m.p.: 107 ºC; IR (KBr, ν_{max}, cm^{-1}): 3278 (NH_2), 3128 (N-H), 3051 (C-H, Ar), 1639 (C=N), 1565 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.75-7.30 (m, 8H, Ar), 7.25 (s, 1H, =CH), 4.63 (s, 2H, NH_2); MS (*m/z*, M^+): 365; Elemental analysis of $C_{17}H_{12}BrN_5$: calcd. (found) %: C, 55.70 (55.75); H, 3.30 (3.30); Br, 21.81 (21.82); N, 19.11 (19.12).

4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-(2-nitrophenyl)-pyrimidin-2-amine (3c): Colour: brown; yield: 75%; m.p.: 130 ºC; IR (KBr, ν_{max}, cm^{-1}): 3270 (NH_2), 3122 (N-H), 3049 (C-H, Ar), 1631 (C=N), 1572 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.71-7.35 (m, 8H, Ar), 7.28 (s, 1H, =CH), 4.58 (s, 2H, NH_2); MS (*m/z*, M^+): 332; Elemental analysis of $C_{17}H_{12}N_6O_2$: calcd. (found) %: C, 61.40 (61.44); H, 3.64 (3.64); N, 25.27 (25.29); O, 9.63 (9.63).

Synthesis of *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenyl-pyrimidin-2-yl)-2-chloroacetamides (4a-c): A mixture of compound **3a-c** (0.01 mol), chloroacetyl chloride (0.01 mol) and triethylamine (TEA) (0.01 mol) in benzene (15 mL) was refluxed on water bath for 3.5 h with gentle stirring. After the completion of reaction, the residue was poured into ice-cold water, filtered and recrystallized from ethyl alcohol to obtain *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-chloroacetamides (**4a-c**).

***N*-(4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-chloroacetamide (4a):** Colour: orange; yield: 80%; m.p.: 144 ºC; IR (KBr, ν_{max}, cm^{-1}): 3241 (N-H), 3115 (N-H), 3052 (C-H, Ar), 2954 (C-H, CH_2), 1650 (C=O), 1646 (C=N), 1562 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.68-7.24 (m, 9H, Ar), 7.31 (s, 1H, =CH), 4.62 (s, 1H, NHCO), 3.65 (s, 1H, NH), 3.26 (s, 2H, CH_2); MS (*m/z*, M^+): 379; Elemental analysis of $C_{20}H_{18}ClN_5O$: calcd. (found) %: C, 63.20 (63.24); H, 4.78 (4.78); Cl, 9.33 (9.33); N, 18.42 (18.44); O, 4.21 (4.21).

***N*-(4-(1*H*-Benzo[*d*] imidazol-2-yl)-6-(2-bromophenyl)-pyrimidin-2-yl)-2-chloroacetamide (4b):** Colour: gray; yield: 74%; m.p.: 131 ºC; IR (KBr, ν_{max}, cm^{-1}): 3255 (N-H), 3121 (N-H), 3048 (C-H, Ar), 2948 (C-H, CH_2), 1652 (C=O), 1644 (C=N), 1557 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ, ppm): 7.65-7.28 (m, 8H, Ar), 7.34 (s, 1H, =CH), 4.68 (s, 1H, NHCO), 3.71 (s, 1H, NH), 3.35 (s, 2H, CH_2); MS (*m/z*, M^+): 441; Elemental analysis of $C_{19}H_{13}BrClN_5O$: calcd. (found) %: C, 51.50 (51.55); H, 2.96 (2.96); Br, 18.03 (18.05); Cl, 8.00 (8.01); N, 15.80 (15.82); O, 3.61 (3.61).

***N*-(4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-(2-nitrophenyl)-pyrimidin-2-yl)-2-chloroacetamide (4c):** Colour: brown; yield: 77%; m.p.: 124 ºC; IR (KBr, ν_{max}, cm^{-1}): 3239 (N-H), 3129 (N-H), 3048 (C-H, Ar), 2963 (C-H, CH_2), 1685 (C=O), 1641 (C=N), 1523 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.76-7.36 (m, 8H, Ar), 7.52 (s, 1H, =CH), 4.68 (s, 1H, NHCO), 3.71 (s, 1H, NH), 3.35 (s, 2H, CH_2); MS (*m/z*, M^+): 408; Elemental analysis of $C_{19}H_{13}ClN_6O_3$: calcd. (found) %: C, 55.78 (55.82); H, 3.21 (3.21); Cl, 8.67 (8.67); N, 20.54 (20.56); O, 11.73 (11.74).

Synthesis of *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenyl-pyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamides (6a-c): A solution consisting of compound **4a-c** (0.01 mol), (*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)-1-phenylprop-2-en-1-one (**5**) (0.01 mol) and K_2CO_3 in DMF was stirred constantly at reflux temperature for 7-11 h. After the completion of reaction, the solution was poured into ice-fold water and precipitated solid was filtered, dried and recrystallized from ethanol to obtain pure compounds **6a-c**.

***N*-(4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamide (6a):** Colour: yellow; yield: 72%; m.p.: 154 ºC; IR (KBr, ν_{max}, cm^{-1}): 3258 (N-H), 3048 (C-H, Ar), 2935 (C-H, CH_2), 1722 (C=O), 1655 (C=O), 1574 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.88-7.31 (m, 19H, Ar-H), 5.49 (s, 1H, NH), 5.28 (d, 1H, *J* = 15.5 Hz, =CH), 5.17 (d, 1H, *J* = 15.5 Hz, =CH), 4.21 (s, 1H, NH), 4.05 (s, 1H, NH), 3.75 (s, 1H, NH), 3.24 (s, 2H, CH_2), 2.85 (t, 4H, *J* = 6.3 Hz, 2 × OCH_2), 2.25 (t, 4H, *J* = 6.3 Hz, 2 × NCH_2); MS (*m/z*, M^+): 725; Elemental analysis of $C_{43}H_{35}N_9O_3$: calcd. (found) %: C, 71.05 (71.16); H, 4.86 (4.86); N, 17.35 (17.37); O, 6.61 (6.61).

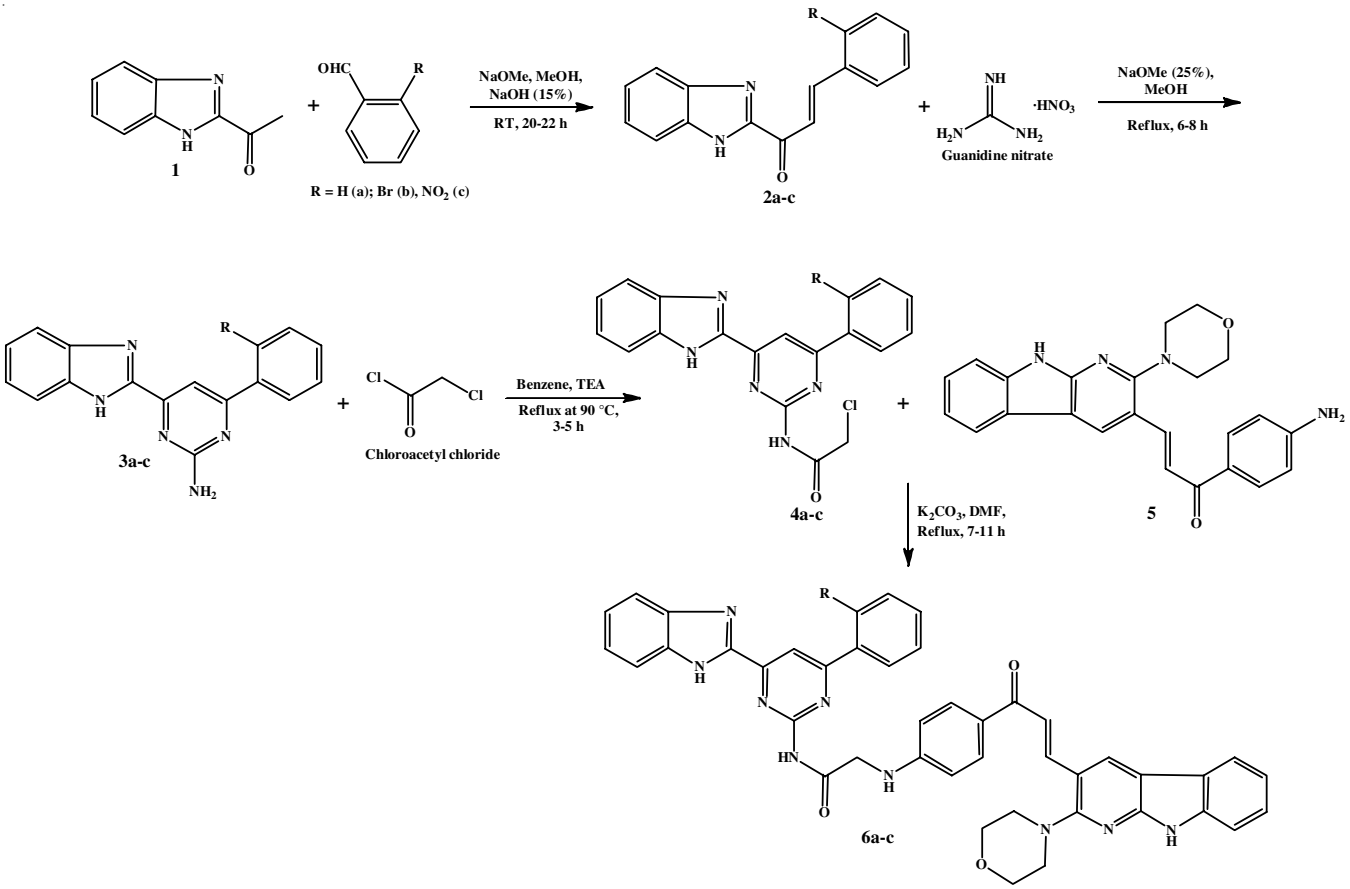
***N*-(4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-(2-bromophenyl)-pyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamide (6b):** Colour: pink; yield: 70%; m.p.: 147 ºC; IR (KBr, ν_{max}, cm^{-1}): 3265 (N-H), 3054 (C-H, Ar), 2947 (C-H, CH_2), 1732 (C=O), 1661 (C=O), 1568 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.81-7.29 (m, 18H, Ar-H), 5.42 (s, 1H, NH), 5.25 (d, 1H, *J* = 15.8 Hz, =CH), 5.21 (d, 1H, *J* = 15.8 Hz, =CH), 4.19 (s, 1H, NH), 4.10 (s, 1H, NH), 3.81 (s, 1H, NH), 3.31 (s, 2H, CH_2), 2.91 (t, 4H, *J* = 6.5 Hz, 2 × OCH_2), 2.21 (t, 4H, *J* = 6.5 Hz, 2 × NCH_2); MS (*m/z*, M^+): 803; Elemental analysis of $C_{43}H_{34}BrN_9O_3$: calcd. (found) %: C, 64.11 (64.18); H, 4.26 (4.26); Br, 9.92 (9.93); N, 15.65 (15.67); O, 5.96 (5.96)

***N*-(4-(1*H*-Benzo[*d*]imidazol-2-yl)-6-(2-nitrophenyl)-pyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamide (6c):** Colour: brown; yield: 71%; m.p.: 136 ºC; IR (KBr, ν_{max}, cm^{-1}): 3250 (N-H), 3048 (C-H, Ar), 2937 (C-H, CH_2), 1728 (C=O), 1674 (C=O), 1572 (C=C, Ar); ^{1}H NMR ($CDCl_3$, 300 MHz, δ ppm): 7.85-7.25 (m, 18H, Ar-H), 5.40 (s, 1H, NH), 5.31 (d, 1H, *J* = 16.0 Hz, =CH), 5.19 (d, 1H, *J* = 16.0 Hz, =CH), 4.23 (s, 1H, NH), 4.15 (s, 1H, NH), 3.88 (s, 1H, NH), 3.41 (s, 2H, CH_2), 2.85 (t, 4H, *J* = 5.8 Hz, 2 × OCH_2), 2.25 (t, 4H, *J* = 5.8 Hz, 2 × NCH_2); MS (*m/z*, M^+): 770; Elemental analysis of $C_{43}H_{34}N_{10}O_5$: calcd. (found) %: C, 66.91 (67.00); H, 4.45 (4.45); N, 18.68 (18.70); O, 10.37 (10.38).

RESULTS AND DISCUSSION

In order to explore the potential therapeutic effects of combining indole, pyrimidopyrimidines and pyrimidobenzimidazoles, a novel fused organic structure was designed to incorporate these bioactive rings into a single molecular framework. In addition, the literature review revealed that there have been no reports on the synthesis of these particular nuclei thus far. As part of our studies on the synthesis of different heterocyclics, in present work, the synthesis of a molecular framework that has four divergent heterocyclic compounds such as imidazole, pyrimidine, morpholine and indole. Following the successful synthesis and chemical structural analysis, several intermediates and title compounds were evaluated for their antibacterial efficacy. The synthesis of the final products is illustrated in **Scheme-I**. The designed title compounds, *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamides **(6a-c)** were synthesized by selecting 1-(1*H*-benzo[*d*]imidazol-2-yl)ethanone **(1)** as raw material.

Thus, the initial intermediate, (*E*)-1-(1*H*-benzo[*d*]imidazol-2-yl)-3-phenylprop-2-ne-1-one (**2a-c**) was obtained from the condensation of 1-(1*H*-benzo[*d*]imidazol-2-yl)ethanone (**1**) with an appropriate aromatic aldehyde in the presence of strong base (sodium methoxide) in methanol solvent at ambient temperature on steady stirring for several hours (**Scheme-I**). The formation of this series of compounds was confirmed by the spectral analysis. For instance, the IR spectrum of compound **2a** showed a strong absorption band at 3180 cm^{-1} due to (N-H) group. In addition, the appearance of two absorption bands at 1748 and 1638 cm^{-1} corresponds to the C=O and C=N stretching vibrations, respectively. In ^{1}H NMR spectrum, the characteristic aromatic hydrogens are resonated as multiplet between δ 7.77-7.72 ppm. Both CH groups of alkene are given signals at δ 5.26 ppm and δ 4.55 ppm as doublets, while the NH signal is located at δ 3.82ppm. The mass spectra were recorded, and



Scheme-I: Synthetic route of fused *N*-heterocyclic compounds containing imidazole, pyrimidine, morpholine and indole moieties

the structure was confirmed by the presence of a molecular ion peak at *m/z* 248, which corresponds to its molecular weight.

Reaction of compounds **2a-c** with guanidine nitrate in the presence of a strong base (NaOMe) in methanol under reflux for 6-8 h yielded the corresponding 4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-amines (**3a-c**). The success of this ring formation was confirmed by IR, ^{1}H NMR and mass spectral analysis of compounds **3a-c**. In IR spectrum of compound **3a**, the characteristic NH_2 and NH groups have been observed at 3262 cm^{-1} and 3138 cm^{-1}, respectively. In addition to the aromatic C-H and C=N signals, Its ^{1}H NMR spectrum showed NH_2 signal at its resonance frequency (δ 4.74 ppm) which is not present in its precursor compound **2a**. The mass spectrum of compound **3a** contains the peak corresponding to its molecular weight at *m/z* 287.

In further step, the final intermediate, *N*-(4-(1*H*-benzo[*d*]-imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-chloroacetamides (**4a-c**) were synthesized from corresponding **3a-c** compound by reacting with chloroacetyl chloride in refluxing benzene for 3-5 h. The structure of compound **4a** was established through spectroscopic (IR, ^{1}H NMR, MS) as well as elemental analysis data. The IR spectrum showed common characteristic absorption bands at 3241 cm^{-1} and 3115 cm^{-1} assigned to both N-H groups. While C=O and C=N groups are displayed their absorption bands at 1650 cm^{-1} and 1646 cm^{-1}. From ^{1}H NMR spectrum, the formation of a signal related to the CH_2 group of compound **4a** as singlet at δ 3.26 ppm was clear evidence for the formation of intermediate **4a**. The mass spectrum showed M^+ ion peak at *m/z* 379 consistent with its molecular formula.

The title compounds, *N*-(4-(1*H*-benzo[*d*]imidazol-2-yl)-6-phenylpyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido-[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamides (**6a-c**) was obtained by reacting compounds **4a-c** with (*E*)-3-(2-morpholino-9*H*-pyrido-[2,3-*b*]indol-3-yl)-1-phenylprop-2-en-1-one (**5**) under mild conditions in refluxing DMF for 7-11 h with uniform stirring. The IR spectrum of compound **6a** clearly showed the presence of a characteristic band at 3258 cm^{-1} as assigned to NH group. In addition, the presence of both C=O groups is confirmed by the absorption bands appeared at 1722 cm^{-1} and 1655 cm^{-1}. In ^{1}H NMR spectrum, the existence of a characteristic singlet at δ 5.49 ppm assigned to the NH group proton confirms the completion of reaction. The mass spectrum of compound **6a** showed M^+ peak at *m/z* 725 in agreement with its molecular formula. The chemical structures of the rest of compounds **6b-c** were identified with their different spectra.

Antibacterial activity: Some of the prepared moieties in the present study **3a-c**, **4a-c** and **6a-c** were examined for their antibacterial activity against three human pathogenic organisms, such as *Staphylococcus typhi*, *Escherichia coli* and *Bacillus subtilis*. The cup-plate method [45] was employed for this examination to determine the zone of inhibition (mm) at a concentration 500 µg. The DMF and norfloxacin are utilized as solvent control and standard drug, respectively and the results are reported in Table-1. As per the screening results, it

TABLE-1
ANTIBACTERIAL ACTIVITY OF COMPOUNDS **3a-c**, **4a-c** AND **6a-c**

Entry	Antibacterial activity (zone of inhibition in mm)		
	S. typhi	*E. coli*	*B. subtilis*
3a	19	20	21
3b	22	20	23
3c	19	22	23
4a	21	23	21
4b	20	22	24
4c	19	24	22
6a	22	21	23
6b	23	20	21
6c	22	24	25
Norfloxacin	26	28	26

was observed that the compounds disclosed fascinating activity, however, with a degree of distinction. Compounds **3b** and **6c** were highly active against *B. subtilis* and *S. typhi* and compounds **4a** and **6a** were highly active against *E. coli* and *B. subtilis*. Compounds **4b**, **3c**, **6b**, **3a** were highly active against *B. subtilis* and compound **3c** was highly active against *E. coli*.

Conclusion

In this work, a new series of fused N-heterocyclic compounds containing imidazole, pyrimidine, morpholine and indole moieties and its derivatives as a novel class of antimicrobial agents were synthesized in multi-step reactions and characterized. Among the synthesized N-(4-(1H-benzo[*d*]imidazol-2-yl)-6-phenyl-pyrimidin-2-yl)-2-(4-((*E*)-3-(2-morpholino-9*H*-pyrido[2,3-*b*]indol-3-yl)acryloyl)phenylamino)acetamides (**6a-c**), compounds **3b** and **6c** exhibited a good antibacterial activity against *B. subtilis* and **S. typhi** while counterpart **6a** and **4a** had shown a good antibacterial activity against *E. coli* and *B. subtilis*, respectively. Additionally, compounds **4b**, **3c**, **6b** and **3a** had the highest antibacterial efficacy against *B. subtilis*. In contrast, compound **3c** demonstrated the maximum significant activity against *E. coli*.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this article.

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