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Synthesis and Antimicrobial Activity of 2-(4-Phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole

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A new series of 4-phenyl-2*H*-chromene-3-benzimidazoles **(8a-o)** were synthesized by the condensation of 4-phenyl-2*H*-chromene-3-carbaldehyde with *o*-phenylene diamines. The products were purified through column chromatography and structures of these compounds were characterized by IR, ^{1}H & ^{13}C NMR and mass spectral data. All the final compounds were screened for their antimicrobial activity and their efficacy were matched with ciprofloxacin. Five compounds (**8b**, **8d**, **8i**, **8l** and **8o)** were found to be most effective compounds of this series and with activities improved than ciprofloxacin under the tested conditions.

Keywords: Michael addition, Chromenes, Suzuki-coupling reaction, Benzimidazoles.

INTRODUCTION

The benzimidazole nucleus is a crucial core in several compounds, acting at different targets to exhibit varied pharmacological properties [1]. An appropriate substitution near the benzimidazole core nucleus resulted in many lead compounds with a dissimilar array of therapeutic properties (Fig. 1). In addition to the biological significance of benzimidazoles, these moieties serve as vital intermediates in frequent organic reactions [1,2] and are also used as fluorescent pigments in optical-electrical devices [3]. The broad efficacy of these moieties has reactive significant determinations concerning their synthesis. Numerous methods have been reported for benzimidazole synthesis. Conservatively, benzimidazoles are commonly synthesised from the reaction of *o*-phenylenediamine through aldehydes, carboxylic acids, nitriles and *o*-esters using dimethylformamide and water at 80-100 ºC [4,5]. Identifying new strategies for synthesising benzimidazoles and functionalising the benzimidazole basic ensures compounds have different presentations in different areas of interest [6]. In past decade, numerous studies have reported different benzimidazoles and their innumerable physiological and pharmacological activities. These studies have focussed on revealing the wide range of drug-like properties of benzimidazole derivatives along with their structure-activity relationships [7-10].

Linking benzimidazole basic scaffold to other heterocyclic moieties including fused rings has improved pharmacological activities. Similarly, chromene moiety is capable of interacting with various cellular targets, which leads to their wide biological activities [11-15]. In this work, new series of 4-phenyl-2*H*-chromene-3-benzimidazoles **(8a-o)** having chromene moiety were synthesized by fusing different heterocyclic rings to the benzimidazoles in order to study the resulting compounds biological activities.

EXPERIMENTAL

All chemicals and solvents were procured from Sigma-Aldrich Chemicals Ltd. and Merck Chemicals Pvt. Ltd. and used without further purification. Melting points were determined with open capillary method and are uncorrected. IR spectra were recorded in KBr arranged Shimadzu IR Affinity-1 FT-IR spectrophotometer and ^{1}H & ^{13}C spectra were recorded on a Bruker Advance II 300 and 400 MHz NMR spectrophotometer in $CDCl_3$/DMSO-d_6 using TMS as internal standard. Mass spectra were recorded on Waters, Q-Tofu Micro mass (LCMS) spectrometer and Varian Inc. 410 Pros tar Binary LC with 500 mass spectrophotometer. Elemental analysis was carried out on a Perkin-Elmer Series-II CHNSO analyzer 2400.

General procedure

Synthesis of 2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo-[*d*]imidazole: The synthesis of 2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo-[*d*]imidazole was carried out by taking a mixture of *o*-phenylenediamine (1 mmol), DMF (5 mL) and water (10

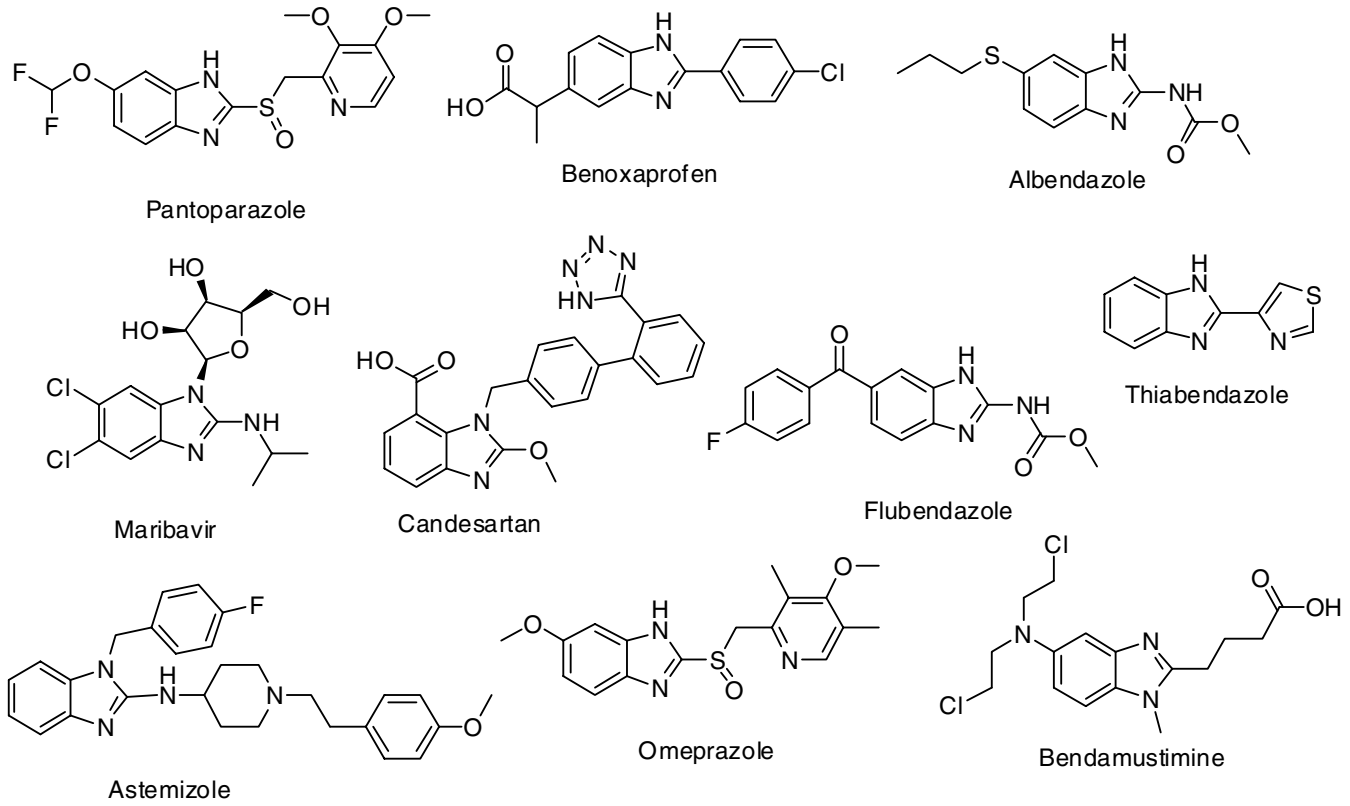


Fig. 1. Multifunctional core of benzimidazoles

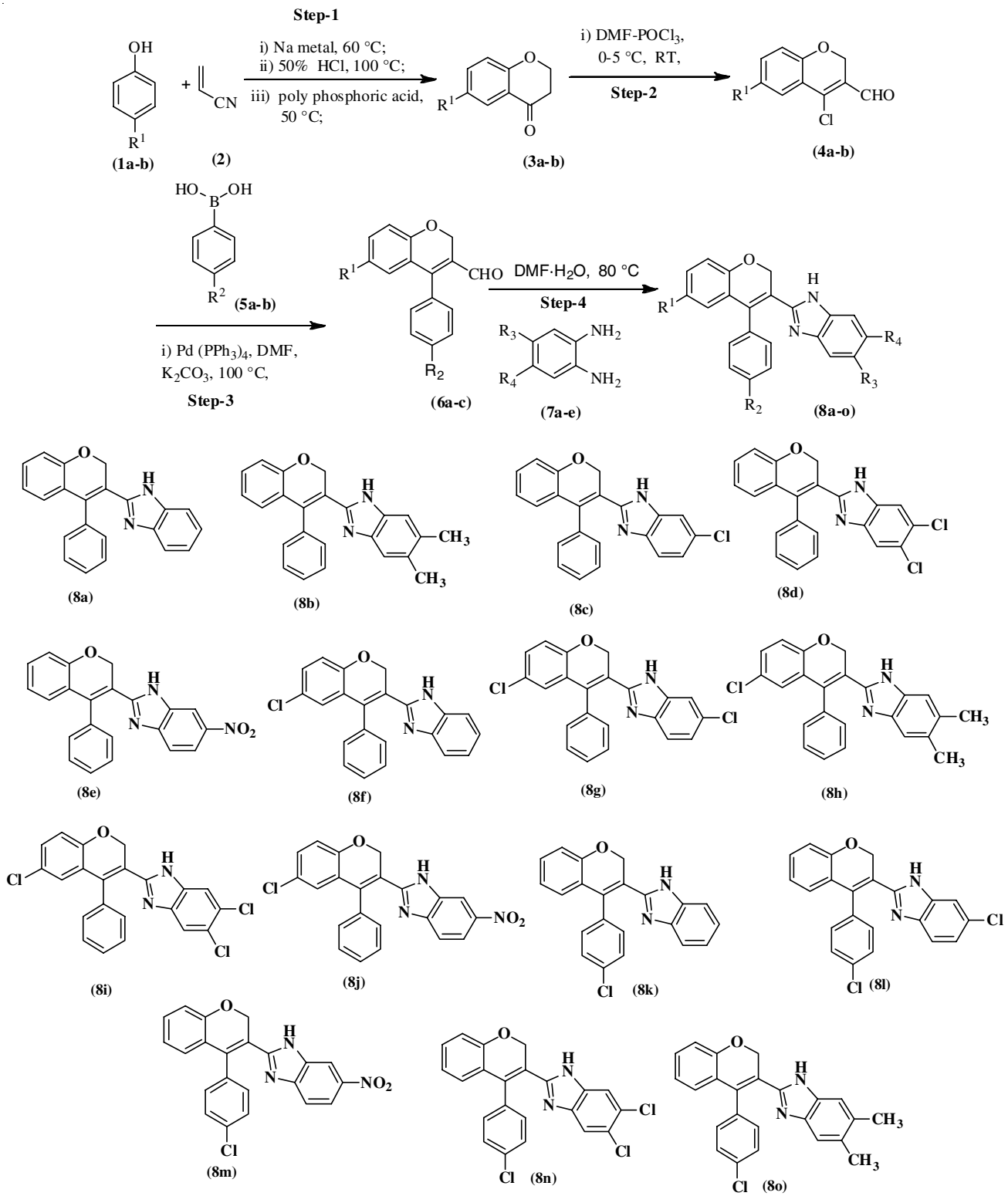
mol%) in a round-bottom flask. To this mixture, added 1.1 mmol of 4-phenyl-2*H*-chromene-3-carbaldehyde and stirred the reaction mixture for 12 h at 80 ºC. After the completion of reaction (monitored by TLC (70:30), hexane:ethyl acetate), the reaction mixture was poured into crushed ice to give solid product, which was washed with distilled water several times and dried. The crude product was purified by column chromatographic technique and the pure solid 2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (**8a**) in good yield was obtained. Similar procedure was adopted for the synthesis of the other derivatives of benzimidazoles (**8b-o**) (**Scheme-I**).

2-(4-Phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8a): Yellow solid, yield: 85%, m.p.: 182-184 ºC. IR (KBr, ν_{max}, cm^{-1}): 3063 (NH), 1597 (C=N) and 1443 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.71 (t, *J* = 10.0 Hz, 1H), 7.69-7.60 (m, 3H), 7.43-7.32 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 110.39, 66.27. ESI-MS (*m/z*): 325 $[M+H]^+$. Elemental anal. of $C_{22}H_{16}N_2O$, calcd. (found) %: C, 81.42 (81.46); H, 4.96 (4.97); N, 8.65 (8.64); O, 4.91 (4.93).

5,6-Dimethyl-2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8b): Yellow solid, yield: 80%, m.p.: 191-193 ºC. IR (KBr, ν_{max}, cm^{-1}): 3062 (NH), 1592 (C=N) and 1448 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.79 (s, *J* = 17.2 Hz, 1H), 7.71 (t, *J* = 12.3 Hz, 1H), 7.68-7.59 (m, 3H), 7.47-7.32 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H) 2.34 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 110.39, 66.27, 18.81. ESI-MS (*m/z*): 352 $[M+H]^+$. Elemental anal. of $C_{24}H_{20}N_2O$, calcd. (found) %: C, 81.73 (81.79); H, 5.76 (5.72); N, 7.85 (7.95); O, 4.73 (4.54).

6-Chloro-2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8c): Light yellow solid, yield: 80%, m.p.: 179-181 ºC. IR (KBr, ν_{max}, cm^{-1}): 3061 (NH), 1591 (C=N) and 1447 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.79 (s, *J* = 16.1 Hz, 1H), 7.71 (t, *J* = 12.5 Hz, 1H), 7.69-7.58 (m, 3H), 7.45-7.33 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 110.21, 66.05. ESI-MS (*m/z*): 359 $[M+H]^+$. Elemental anal. of $C_{22}H_{15}N_2OCl$, calcd. (found) %: C, 73.68 (73.64); H, 4.24 (4.21); N, 7.79 (7.81); O, 4.48 (4.46); Cl, 9.86 (9.88).

5,6-Dichloro-2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8d): Yellow solid, yield: 83%, m.p.: 209-211 ºC. IR (KBr, ν_{max}, cm^{-1}): 3015 (NH), 1592 (C=N) and 1431 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.69-7.58 (m, 3H), 7.42-7.33 (m, 2H), 7.19-7.12 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.58 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.93, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72,



Scheme-I: Synthesis of 2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazoles

122.52, 121.54, 119.65, 118.86, 116.24, 110.39, 66.64. ESI-MS (*m/z*): 392 $[M+H]^+$. Elemental anal. of $C_{22}H_{14}N_2OCl_2$, calcd. (found) %: C, 67.20 (67.19); H, 3.61 (3.59); N, 7.16 (7.12); O, 4.04 (4.07); Cl, 18.00 (18.03).

6-Nitro-2-(4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]-imidazole (8e): Light yellow solid, yield: 78%, m.p.: 173-176 ºC. IR (KBr, ν_{max}, cm^{-1}): 3058 (NH), 1590 (C=N) 1564, 1360 (NO_2) and 1437 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.71 (t, *J* = 10.4 Hz, 1H), 7.67-7.61 (m, 3H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.23-7.11 (m, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49,

142.69, 136.79, 136.27, 133.26, 130.64, 130.27, 129.62, 129.26, 127.16, 124.75, 123.91, 122.71, 121.69, 119.91, 118.70, 116.42, 110.71, 66.05. ESI-MS (*m/z*): 369 $[M+H]^+$. Elemental anal. of $C_{22}H_{15}N_3O_3$, calcd. (found) %: C, 71.56 (71.54); H, 4.07 (4.09); N, 11.35 (11.38); O, 13.00 (12.99).

2-(6-Chloro-4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]-imidazole (8f): Light yellow solid, yield: 76%, m.p.: 179-181 ºC. IR (KBr, ν_{max}, cm^{-1}): 3061 (NH), 1590 (C=N) and 1438 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.79 (d, *J* = 17.2 Hz, 1H), 7.71 (t, *J* = 12.3 Hz, 1H), 7.68-7.59 (m, 3H), 7.47-7.32 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 110.39, 66.27. ESI-MS (*m/z*): 359 $[M+H]^+$. Elemental anal. of $C_{22}H_{15}N_2OCl$, calcd. (found) %: C, 73.66 (73.64); H, 4.23 (4.21); N, 7.82 (7.81); O, 4.42 (4.46); Cl, 9.86 (9.88).

6-Chloro-2-(6-chloro-4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8g): White solid, yield: 78%, m.p.: 168-170 ºC. IR (KBr, ν_{max}, cm^{-1}): 3057 (NH), 1592 (C=N) and 1439 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.67-7.62 (m, 3H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.16 (dd, *J* = 8.4, 6.1 Hz, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.85, 148.27, 142.38, 136.65, 136.02, 133.17, 130.46, 129.86, 129.62, 129.02, 124.75, 123.56, 122.52, 121.26, 119.65, 118.97, 116.42, 110.21, 66.56. ESI-MS (*m/z*): 393 $[M+H]^+$. Elemental anal. of $C_{22}H_{14}N_2OCl_2$, calcd. (found) %: C, 67.17 (67.19); H, 3.58 (3.59); Cl, 18.01 (18.03); N, 7.14 (7.12); O, 4.05 (4.07).

2-(6-Chloro-4-phenyl-2*H*-chromen-3-yl)-5,6-dimethyl-1*H*-benzo[*d*]imidazole (8h): Brown solid, yield: 78%, m.p.: 148-150 ºC. IR (KBr, ν_{max}, cm^{-1}): 3028 (NH), 1607 (C=N) and 1422 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.79 (s, *J* = 17.2 Hz, 1H), 7.71 (t, *J* = 12.3 Hz, 1H), 7.68-7.59 (m, 2H), 7.47-7.32 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.58 (s, 2H), 2.34 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.69, 119.65, 118.78, 116.24, 110.39, 66.39, 18.65. ESI-MS (*m/z*): 387 $[M+H]^+$. Elemental anal. of $C_{24}H_{19}N_2OCl$, calcd. (found) %: C, 74.54 (74.51); H, 4.91 (4.95); N, 7.22 (7.24); O, 4.12 (4.14); Cl, 9.18 (9.16).

5,6-Dichloro-2-(6-chloro-4-phenyl-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8i): White solid, yield: 78%, m.p.: 165-167 ºC. IR (KBr, ν_{max}, cm^{-1}): 3003 (NH), 1607 (C=N) and 1440 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.64 (d, *J* = 2.6 Hz, 2H), 7.39-7.37 (m, 1H), 7.18-7.14 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 154.37, 148.72, 142.75, 136.65, 136.02, 133.26, 130.46, 129.99, 129.62, 129.07, 126.90, 124.55, 124.42, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 109.99, 66.13. ESI-MS (*m/z*) 428 $[M+2]^+$. Elemental anal. of $C_{22}H_{13}N_2OCl_3$, calcd. (found) %: C, 61.78 (61.77); H, 3.06 (3.05); N, 6.55 (6.53); O, 3.74 (3.76); Cl, 24.87 (24.87).

2-(6-Chloro-4-phenyl-2*H*-chromen-3-yl)-6-nitro-1*H*-benzo[*d*]imidazole (8j): Brown solid, yield: 74%, m.p.: 193-196 ºC. IR (KBr, ν_{max}, cm^{-1}): 3006 (NH), 1613 (C=N) 1564, 1360 (NO_2) and 1445 cm^{-1} (C=C). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.82 (s, 1H), 7.71 (t, *J* = 10.4 Hz, 1H), 7.67-7.61 (m, 3H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.23-7.11 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 158.79, 155.93, 153.19, 148.04, 134.66, 131.12, 130.18, 130.04, 129.75, 126.35, 124.53, 119.85, 119.71, 117.62, 110.48, 66.49. ESI-MS (*m/z*) 404 $[M+H]^+$. Elemental anal. of $C_{22}H_{14}N_3O_3Cl$, calcd. (found) %: C, 65.45 (65.43); H, 3.44 (3.49); N, 10.44 (10.41); O, 11.86 (11.89); Cl, 8.71 (8.78).

2-(4-(4-Chlorophenyl)-2*H*-chromen-3-yl)-1*H*-benzo-[*d*]imidazole (8k): Brown solid, yield: 80%, m.p.: 171-173 ºC. IR (KBr, ν_{max}, cm^{-1}): 3064 (NH), 1598 (C=N) and 1443 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.81 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.67-7.62 (m, 3H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.22-7.11 (m, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 154.19, 148.65, 142.54, 136.56, 136.27, 133.26, 130.46, 130.11, 129.74, 129.62, 127.00, 124.63, 123.72, 122.52, 121.54, 119.65, 118.86, 116.24, 110.39, 66.27. ESI-MS (*m/z*): 359 $[M+H]^+$. Elemental anal. of $C_{22}H_{15}N_2OCl$, calcd. (found) %: C, 73.62 (73.64); H, 4.23 (4.21); N, 7.83 (7.81); O, 4.42 (4.46); Cl, 9.86 (9.88).

6-Chloro-2-(4-(4-chlorophenyl)-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8l): Yellow solid, yield: 68%, m.p.: 181-183 ºC. IR (KBr, ν_{max}, cm^{-1}): 3062 (NH), 1590 (C=N) and 1448 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.82 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.67-7.63 (m, 3H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.21-7.13 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 158.79, 155.93, 153.19, 148.04, 134.66, 131.12, 130.18, 130.04, 129.75, 126.52, 126.35, 126.13, 124.53, 120.30, 119.85, 119.71, 117.62, 110.48, 66.49. ESI-MS (*m/z*): 393 $[M+H]^+$. Elemental anal. of $C_{22}H_{14}N_2OCl_2$, calcd. (found) %: C, 67.12 (67.19); H, 3.56 (3.59); N, 7.10 (7.12); O, 4.08 (4.07); Cl, 18.05 (18.03).

2-(4-(4-Chlorophenyl)-2*H*-chromen-3-yl)-6-nitro-1*H*-benzo[*d*]imidazole (8m): Yellow solid, yield: 72%, m.p.: 208-210 ºC. IR (KBr, ν_{max}, cm^{-1}): 3015 (NH), 1593 (C=N) 1564, 1360 (NO_2) and 1431 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.80 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.66-7.63 (m, 2H), 7.38 (dd, *J* = 6.4, 2.9 Hz, 2H), 7.20-7.13 (m, 3H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 154.52, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.75, 119.96, 118.62, 116.42, 110.61, 66.27. ESI-MS (*m/z*): 404 $[M+H]^+$. Elemental anal. of $C_{22}H_{14}N_3O_3Cl$, calcd. (found) %: C, 64.43 (65.43); H, 3.47 (3.49); N, 10.43 (10.41); O, 11.89 (11.88); Cl, 8.72 (8.78).

5,6-Dichloro-2-(4-(4-chlorophenyl)-2*H*-chromen-3-yl)-1*H*-benzo[*d*]imidazole (8n): Light yellow solid, yield: 78%, m.p.: 189-191 ºC. IR (KBr, ν_{max}, cm^{-1}): 3061 (NH), 1590 (C=N) and 1438 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.82 (s, 1H), 7.72 (d, *J* = 7.6 Hz, 1H), 7.66-7.63 (m, 2H), 7.38 (dd, *J* = 6.4,

2.9 Hz, 2H), 7.20-7.13 (m, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H). ^{13}C NMR (101 MHz, $CDCl_3$): δ 158.44, 155.29, 153.02, 148.04, 142.40, 134.57, 131.12, 130.04, 126.81, 124.53, 124.07, 119.31, 117.31, 110.48, 66.49.ESI-MS (*m/z*): 428 $[M+2]^+$. Elemental anal. of $C_{22}H_{13}N_2OCl_3$, calcd. (found) %: C, 61.74 (61.78); H, 3.04 (3.06); N, 6.51 (6.55); O, 3.72 (3.74); Cl, 24.85 (24.87).

2-(4-(4-Chlorophenyl)-2*H*-chromen-3-yl)-5,6-dimethyl-1*H*-benzo[*d*]imidazole (8o): Light yellow solid, yield: 80%, m.p.: 183-185 ºC. IR (KBr, ν_{max}, cm^{-1}): 3058 (NH), 1590 (C=N) and 1437 (C=C). ^{1}H NMR (400 MHz, $CDCl_3$) δ ppm: 7.79 (s, *J* = 17.2 Hz, 1H), 7.71 (t, *J* = 12.3 Hz, 1H), 7.68-7.59 (m, 2H), 7.47-7.32 (m, 2H), 7.18 (ddd, *J* = 15.1, 10.9, 8.8 Hz, 2H), 7.03 (d, *J* = 7.6 Hz, 1H), 6.92 (d, *J* = 8.6 Hz, 1H), 6.64 (d, *J* = 2.3 Hz, 1H), 5.57 (s, 2H), 2.34 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ ppm: 154.63, 148.49, 142.54, 136.65, 136.27, 133.26, 130.46, 130.11, 129.62, 129.26, 127.00, 124.63, 123.72, 122.52, 121.69, 119.65, 118.78, 116.24, 110.39, 66.27, 18.78. ESI-MS (*m/z*): 387 $[M+H]^+$. Elemental anal. of $C_{24}H_{19}N_2OCl$, calcd. (found) %: C, 74.49 (74.51); H, 4.90 (4.95); N, 7.24 (7.24); O, 4.12 (4.14); Cl, 9.14 (9.16).

RESULTS AND DISCUSSION

Antibacterial activity: All the newly synthesized compounds **(8a-o)** were evaluated for their antibacterial activity against *Escherichia coli*, *Staphylococcus aureus*, *Pseudomonas aeruginosa* and *Bacillus subtilis* at different 20, 30, 40,100 and 200 µg/mL concentration and the ciprofloxacin was used as standard reference drug. The antibacterial activity was determined by agar well diffusion technique with slight modifications [16]. Among the 15 synthesized derivatives **8a-o**, only 5 compounds (**8b**, **8d**, **8i**, **8l** and **8o)** showed very high activity against all the studied four bacterial strains (Table-1).

Antifungal activity: Using the disc diffusion method [16], the antifungal activity of compounds **(8a-o)** against *Aspergillus niger* and *Candida albicans* was tested at 100 and 200 µg/mL utilizing standard reference drug voriconazole. The results revealed that compounds **(8b**, **8d**, **8i**, **8l** and **8o)** showed the highest biological activities (Table-1).

TABLE-1
ANTIBACTERIAL AND ANTIFUNGAL ACTIVITY OF NEWLY SYNTHESIZED COMPOUNDS (**8a-o**)

Compounds	Conc. (µg/mL)	Zone of inhibition (mm)					
		Antibacterial activity				Antifungal activity	
		Staphylococcus aureus	*Bacillus subtilis*	*Escherichia coli*	*Pseudomonas aeruginosa*	*Aspergillus niger*	*Candida albicans*
8a	100	16.0	18.00	23.00	29.0	20.0	22.3
	200	18.0	15.00	24.00	21.0	21.0	23.0
8b	100	22.0	20.00	25.50	32.0	26.5	24.0
	200	23.5	21.50	26.00	33.0	28.0	25.3
8c	100	18.5	15.00	25.00	28.0	26.0	22.0
	200	20.0	19.00	26.00	27.0	26.0	24.0
8d	100	22.0	20.00	25.00	31.0	27.5	24.0
	200	23.0	21.00	26.00	32.0	29.0	25.6
8e	100	16.0	16.00	19.00	20.0	26.0	21.0
	200	17.0	17.00	20.00	21.0	27.0	21.1
8f	100	17.0	16.50	19.00	20.0	26.0	21.6
	200	16.0	17.50	15.00	24.0	22.0	22.0
8g	100	19.5	17.01	12.00	21.0	21.0	23.0
	200	20.0	19.00	13.00	25.0	23.0	23.0
8h	100	16.0	16.20	14.00	28.0	24.5	20.0
	200	18.0	17.30	15.00	19.0	26.3	17.0
8i	100	23.0	20.00	26.00	30.0	27.0	23.5
	200	23.0	21.00	27.00	31.0	29.0	25.3
8j	100	14.0	18.00	26.00	27.0	16.0	14.0
	200	16.0	15.00	16.25	29.0	19.0	20.0
8k	100	17.0	16.00	17.20	21.5	20.0	23.0
	200	19.0	18.00	16.25	22.0	21.0	20.0
8l	100	22.0	20.00	25.00	31.0	27.0	23.3
	200	23.0	21.00	26.00	32.0	29.0	25.2
8m	100	16.0	12.00	15.00	24.0	23.0	21.0
	200	17.0	14.00	16.00	29.0	22.0	23.8
8n	100	16.8	15.00	19.00	26.0	26.0	20.0
	200	17.2	16.00	20.00	29.0	21.0	19.0
8o	100	22.3	20.00	25.00	31.0	27.0	23.0
	200	23.5	21.00	26.50	32.0	29.0	24.0
Ciprofloxacin	100	23.0	21.00	26.00	32.0	–	–
	200	24.0	22.00	27.00	33.0	–	–
Voriconazole	100	–	–	–	–	28.0	24.0
	200	–	–	–	–	30.0	26.0

Conclusion

A series of novel 4-phenyl-2*H*-chromene-3-benzimidazoles **(8a-o)** were synthesized by the condensation of 2,4-phenyl-2*H*-chromene-3-carbaldehyde and *o*-phenylenediamines. All the compounds were characterized successfully. Among the newly synthesized substituted benzimidazoles, 5 compounds (**8b**, **8d**, **8i**, **8l** and **8o)** showed a excellent antibacterial and antifungal activities.

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CONFLICT OF INTEREST

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

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