

SYNTHESIS AND CHARACTERIZATION OF OXADIAZOLE DERIVATIVES FROM BENZIMIDAZOLE

(Sintesis dan Perincian Terbitan Oksadiazol Dari Benzimidazol)

Norizan Ahmat^{1,2*}, Nik Khairunissa Nik Abdullah Zawawi^{1,2}, Muhammad Taha^{1,2}, Nor Hadiani Ismail^{1,2},
Noraishah Abdullah¹

¹Faculty of Applied Sciences,

Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

²Atta-ur-Rahman Institute for Natural Product Discovery,

Universiti Teknologi MARA, Puncak Alam Campus, 42300 Bandar Puncak Alam, Selangor, Malaysia

*Corresponding author: noriz118@salam.uitm.edu.my

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Abstract

Heterocyclic compounds of benzimidazole and oxadiazole are considered as important class of compounds in medicinal chemistry because of their interesting diversified biological activities. A series of new benzimidazole bearing oxadiazole derivatives have been conveniently synthesized by intermolecular oxidative cyclization of benzimidazole benzoyl hydrazide promoted by iodobenzene diacetate as an oxidant. The structures of the synthesized compounds were characterized by spectroscopic methods namely ¹H Nuclear Magnetic Resonance (NMR), Infrared (IR), Mass Spectrometry (MS) and melting point.

Keywords: synthesis, benzimidazole, oxadiazole, hydrazide, nuclear magnetic resonance

Abstrak

Sebatian heterosiklik daripada benzimidazol dan oksadiazol dianggap sebagai satu kelas sebatian penting dalam kimia perubatan kerana aktiviti biologinya yang pelbagai. Satu siri baru terbitan oksadiazol dari benzimidazol telah disintesis dengan mudah oleh siklisasi oksidatif antara molekul daripada benzoil hidrazida benzimidazol dimangkin oleh diasetat iodobenzena sebagai oksidan. Struktur sebatian disintesis telah dicirikan oleh kaedah spektroskopik seperti ¹H Resonans Magnet Nukleus (NMR), Inframerah (IR), Spektrometri Jisim (MS) dan takat lebur.

Kata kunci: sintesis, benzimidazol, oxadiazol, hidrazida, resonan megnetik nukleus

Introduction

Benzimidazole and oxadiazole have received attention in recent years due to widespread applications notably in the field of medicinal chemistry due to their privileged biological activity. Recently, benzimidazole derivatives have been reported as antidiabetic [1], antimicrobial [2-3], antiviral [4-6] antispasmodic [7] and antiasthmatic [8] agents. Similarly, oxadiazole derivatives are also recognized for their pharmacological importance and are reported to possess wide spectrum of activities such as antibacterial [9-11], antifungal [12] anti-inflammatory [13-14] analgesic [15], anticonvulsant [16-17], hypoglycemic [18] and anticancer [19] properties. The synthesis of both compounds has emerged as an essential need for development of new pharmaceutical entities.

In the present study, a series of novel oxadiazoles were synthesized from benzimidazole and their physical characterization are reported. The structures of the synthesized compounds were characterized using different spectroscopic methods namely ^1H Nuclear Magnetic Resonance (NMR), Infrared (IR), Mass Spectrometry (MS) and melting point.

Materials and Methods

Melting point was taken on Buchi M-560 melting point instrument and was uncorrected. IR spectra were recorded on a Spectrum One FT-IR spectrometer (Perkin Elmer), using KBr discs and values were signified in cm^{-1} . The ^1H NMR and ^{13}C NMR spectra were measured on Bruker 500 Ultrashield Plus NMR (500 MHz) in $\text{DMSO-}d_6$ as solvent, using tetramethylsilane (TMS) as an internal standard, and chemical shifts are expressed as ppm. ESI MS were determined on Agilent 6330 Ion Trap, using positive/negative mode. HR-ESI-MS were determined on Agilent 6224 TOF-LC/MS using positive mode.

Synthesis of methyl 4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)benzoate (a)

Sodium metasilicate adduct was synthesized according to literature protocol [20]. Equimolar solution of sulphite adduct and 4,5-dimethyl-*O*-phenylenediamine in DMF was refluxed for 6 hours. After the completion of reaction, it was poured into ice water and the solid product (a) was filtered, dried and crystallized.

Synthesis of 4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)benzohydrazide (b)

A solution of compound (a) (40 mmol) in methanol (50 ml) was refluxed for 12 hours in the presence of hydrazine hydrate (95%) mixture (10 ml). The reaction mixture was evaporated and the residue was washed with water, filtered, dried, and crystallized.

General procedure for the synthesis of 4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl) benzohydrazide Schiff bases (1-14)

Equimolar mixture of 4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl) benzohydrazide (0.280 g, 0.01 mol) selected aldehyde (0.01 mol), in *n*-butanol (25 mL) containing acetic acid (1 mL) was heated under reflux for 3 hours. The reaction mixture was filtered, dried and crystallized.

General procedure for the synthesis of 2,5-disubstituted-1,3,4-oxadiazoles (15-28)

Compounds **1-14** (100 mg, ± 0.25 mmol) were dissolved in DMF (5 ml) and iodobenzenediacetate (IBD) (± 0.27 mmol) were added [21]. The content was stirred overnight and the progress of reaction was monitored by thin layer chromatography. Cold water was added and the precipitate obtained was filtered, washed with diethyl ether and dried to afford **15-28**.

Results and Discussion

Characterization: methyl 4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)benzoate (a)

Light brown solid; yield (96%); m.p. 208.9°C ; IR(KBr) (ν_{max} , cm^{-1}): 2954, 1720, 1273, 1107. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 3.88 (s, 3H, OCH_3 -benzoate), 7.39 (s, 2H, H-4,7-benzimidazole), 8.09 (d, $J = 8.4$ Hz, 2H, Ar), 8.27 (d, $J = 8.4$ Hz, 2H, Ar). ESI MS (m/z): 280.1 (M^+).

4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)benzohydrazide (b)

Light brown solid; yield (93%); m.p. 316.5°C ; IR(KBr) (ν_{max} , cm^{-1}): 3020, 1625, 1560, 1350. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 4.56 (s, 2H, NH_2), 7.32 (s, 1H, H-7-benzimidazole), 7.46 (s, 1H, H-4-benzimidazole), 7.98 (d, $J = 7.5$ Hz, 2H, Ar), 8.21 (d, $J = 7.5$ Hz, 2H, Ar), 9.88 (s, 1H, NH-hydrazide), 12.74 (s, 1H, NH-benzimidazole). ESI MS (m/z): 280.1 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(3-fluorobenzylidene) benzohydrazide (1)

Light brown solid; yield 89%; m.p. 324.3°C ; IR(KBr) (ν_{max} , cm^{-1}): 3465, 1657, 1557, 1276, 1237. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 7.31 (m, 2H, Ar), 7.55 (m, 4H, Ar), 8.09 (d, $J = 7.7$ Hz, 2H, Ar), 8.29 (d, $J = 8.0$ Hz, 2H, Ar), 8.51 (s, 1H, $\text{CH}=\text{N}$), 12.05 (s, 1H, NH-hydrazide), 12.80 (s, 1H, NH-benzimidazole). ESI MS (m/z): 386.2 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(2-hydroxybenzylidene) benzohydrazide (2)

Light brown solid; yield (90%); m.p. 352.7 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3427, 1623, 1291. ^1H NMR (500 MHz, DMSO) δ : 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 6.99 – 6.92 (m, 2H, Ar), 7.33 (t, $J = 7.7$ Hz, 1H, Ar), 7.41 (s, 2H, H-4,7-benzimidazole), 7.58 (d, $J = 7.4$ Hz, 1H, Ar), 8.11 (d, $J = 8.2$ Hz, 2H, Ar), 8.30 (d, $J = 8.2$ Hz, 2H, Ar), 8.69 (s, 1H, $\text{CH}=\text{N}$), 11.28 (s, 1H, NH-hydrazide), 12.19 (s, 1H, NH-benzimidazole). ESI MS (m/z): 384.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(3-hydroxybenzylidene) benzohydrazide (3)

Light yellow solid; yield (90%); m.p. 316.1 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3200, 1642, 1560, 1271. ^1H NMR (500 MHz, DMSO) δ : 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 7.13 (d, $J = 7.2$ Hz, 1H, Ar), 7.24 (s, 1H, Ar), 7.28 (t, $J = 7.7$ Hz, 1H, Ar), 7.41 (s, 2H, H-4,7-benzimidazole), 8.08 (d, $J = 7.9$ Hz, 2H, Ar), 8.28 (d, $J = 8.0$ Hz, 2H, Ar), 8.41 (s, 1H, $\text{CH}=\text{N}$), 9.66 (s, 1H, OH), 11.88 (s, 1H, NH-hydrazide), 12.80 (d, $J = 1.0$ Hz, 1H, NH-benzimidazole). ESI MS (m/z): 384.3 (M^+).

(E)-N'-(3,4-dimethoxybenzylidene)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl) benzohydrazide (4)

Light yellow solid; yield (92%); m.p. 316.4 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3434, 1658, 1564, 1272. ^1H NMR (500 MHz, DMSO) δ : 2.35, 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 3.84 (s, 6H, OCH_3 -3,4-Ar), 7.05 (d, $J = 8.2$ Hz, 1H, Ar), 7.23 (d, $J = 7.8$ Hz, 1H, Ar), 7.33 (s, 1H, Ar), 7.38 (s, 1H, Ar), 7.47 (s, 1H, Ar), 8.07 (d, $J = 8.1$ Hz, 2H, Ar), 8.28 (d, $J = 8.1$ Hz, 2H, Ar), 8.42 (s, 1H, $\text{CH}=\text{N}$), 11.83 (s, 1H, NH-hydrazide), 12.81 (s, 1H, NH-benzimidazole). ESI MS (m/z): 428.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(4-nitrobenzylidene) benzohydrazide (5)

Light yellow solid; yield (92%); m.p. 323.6 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3269, 1637, 1560, 1519, 1343, 1282. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 7.32 (s, 1H, H-7), 7.46 (s, 1H, H-4), 8.00 (d, $J = 8.1$ Hz, 2H, Ar), 8.09 (d, $J = 7.7$ Hz, 2H, Ar), 8.32 – 8.27 (m, 4H, Ar), 8.57 (s, 1H, $\text{CH}=\text{N}$), 12.23 (s, 1H, NH-hydrazide), 12.83 (s, 1H, NH-benzimidazole). ESI MS (m/z): 413.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(4-fluorobenzylidene) benzohydrazide (6)

Light brown solid; yield (94%); m.p. 330.7 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3256, 1630, 1287, 1236. ^1H NMR (500 MHz, DMSO) δ : 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 7.32 (t, $J = 8.6$ Hz, 2H, Ar), 7.40 (s, 2H, Ar), 7.87 – 7.78 (m, 2H, Ar), 8.08 (d, $J = 8.0$ Hz, 2H, Ar), 8.28 (d, $J = 8.1$ Hz, 2H, Ar), 8.49 (s, 1H, $\text{CH}=\text{N}$), 11.96 (s, 1H, NH-benzimidazole). ESI MS (m/z): 386.9 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(4-methoxybenzylidene) benzohydrazide (7)

Light brown solid; yield (91%); m.p. 276.0 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3234, 1611, 1512, 1258. ^1H NMR (500 MHz, DMSO) δ : 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 3.82 (s, 3H, OCH_3), 7.04 (d, $J = 8.6$ Hz, 2H, Ar), 7.51 – 7.29 (m, 2H, Ar), 7.71 (d, $J = 8.5$ Hz, 2H, Ar), 8.08 (d, $J = 8.2$ Hz, 2H, Ar), 8.28 (d, $J = 8.2$ Hz, 2H, Ar), 8.44 (s, 1H, $\text{CH}=\text{N}$), 11.83 (s, 1H, NH-benzimidazole). ESI MS (m/z): 398.9 (M^+).

(Z)-N'-(4-chlorobenzylidene)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)benzohydrazide (8)

Light brown solid; yield (90%); m.p. 338.7 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3253, 1634, 1565, 1286, 669. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.33 (s, 1H, Ar), 7.47 (s, 1H, Ar), 7.55 (d, $J = 8.0$ Hz, 2H, Ar), 7.79 (d, $J = 8.1$ Hz, 2H, Ar), 8.08 (d, $J = 7.9$ Hz, 2H, Ar), 8.28 (d, $J = 8.0$ Hz, 2H, Ar), 8.49 (s, 1H, $\text{CH}=\text{N}$), 12.01 (s, 1H, NH-hydrazide), 12.80 (s, 1H, NH-benzimidazole). ESI MS (m/z): 402.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(pyridin-4-ylmethylene) benzohydrazide (9)

Light brown solid; yield (90%); m.p. 306.7 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3277, 1634, 1560, 1288. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 7.40 (s, 2H, Ar), 7.69 (s, 2H, Ar), 8.10 (d, $J = 7.2$ Hz, 2H, Ar), 8.30 (d, $J = 7.9$ Hz, 2H, Ar), 8.48 (s, 1H, $\text{CH}=\text{N}$), 8.67 (s, 2H, Ar), 12.22 (s, 1H, NH-benzimidazole). ESI MS (m/z): 369.3 (M^+).

(E)-N'-(3-chlorobenzylidene)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl) benzohydrazide (10)

Light brown solid; yield (91%); m.p. 358.5 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3422 (NH), 1651, 1564, 1282, 704. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 7.40 (s, 2H, Ar), 7.49 (s, 2H, Ar), 7.71 (s, 1H, Ar), 7.81

(s, 1H, Ar), 8.09 (d, $J = 7.6$ Hz, 2H, Ar), 8.29 (d, $J = 7.8$ Hz, 2H, Ar), 8.47 (s, 1H, CH=N), 12.09 (s, 1H, NH-benzimidazole). ESI MS (m/z): 402.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(2-methylbenzylidene) benzohydrazide (11)

Light brown solid; yield (93%); m.p. 323.8 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3057 (NH), 1637, 1275. ^1H NMR (500 MHz, DMSO) δ : 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 2.47 (s, 3H, CH_3), 7.35 – 7.26 (m, 3H, Ar), 7.40 (s, 2H, H-4,7-benzimidazole), 7.89 (d, $J = 7.3$ Hz, 1H, Ar), 8.10 (d, $J = 8.0$ Hz, 2H, Ar), 8.29 (d, $J = 8.0$ Hz, 2H, Ar), 8.80 (s, 1H, CH=N), 11.92 (s, 1H, NH-benzimidazole). ESI MS (m/z): 382.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(4 hydroxybenzylidene) benzohydrazide (12)

Light yellow solid; yield (91%); m.p. 313.4 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3198 (NH), 1610, 1272. ^1H NMR (500 MHz, DMSO) δ : 2.35 (s, 6H, CH_3 -5,6), 6.86 (d, $J = 8.2$ Hz, 2H, Ar), 7.40 (s, 2H, H-4,7-benzimidazole), 7.59 (d, $J = 8.2$ Hz, 2H, Ar), 8.07 (d, $J = 8.1$ Hz, 2H, Ar), 8.27 (d, $J = 8.1$ Hz, 2H, Ar), 8.39 (s, 1H, CH=N), 9.95 (s, 1H, NH-hydrazide), 11.74 (s, 1H, NH-benzimidazole). ESI MS (m/z): 384.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(pyridin-3-ylmethylene) benzohydrazide (13)

Light yellow solid; yield (92%); m.p. 348.3 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3194, 1647, 1552, 1281. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 7.40 (s, 2H, Ar), 7.50 (s, 1H, Ar), 8.10 (d, $J = 7.5$ Hz, 2H, Ar), 8.17 (d, $J = 6.9$ Hz, 1H, Ar), 8.30 (d, $J = 7.7$ Hz, 2H, Ar), 8.55 (s, 1H, Ar), 8.63 (s, 1H, Ar), 8.89 (s, 1H, CH=N), 12.12 (s, 1H, NH-hydrazide), 12.81 (s, 1H, NH-benzimidazole). ESI MS (m/z): 369.3 (M^+).

(E)-4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)-N'-(3 methylbenzylidene) benzohydrazide (14)

White solid; yield (93%); m.p. 321.2 °C; IR(KBr) ($\nu_{\max}$, cm^{-1}): 3422, 1656, 1564, 1283. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.35, 2.38 (s, 9H, 3CH_3 -5,6-benzimidazole, 3''-Ar), 7.27 (d, $J = 6.9$ Hz, 1H, Ar), 7.33 (s, 1H, H-7), 7.37 (t, $J = 7.3$ Hz, 1H, Ar), 7.47 (s, 1H, H-4), 7.54 (d, $J = 7.1$ Hz, 1H, Ar), 7.59 (s, 1H, H-2''), 8.08 (d, $J = 7.6$ Hz, 2H, Ar), 8.28 (d, $J = 7.8$ Hz, 2H, Ar), 8.46 (s, 1H, CH=N), 11.93 (s, 1H, NH-hydrazide), 12.82 (s, 1H, NH-benzimidazole). ESI MS (m/z): 382.3 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(3-fluorophenyl)-1,3,4-oxadiazole (15)

Pale yellow powder, yield: 0.075 g (75%), m.p.: 346.5 °C. IR (KBr) ($\nu_{\max}$, cm^{-1}): 3308, 1611, 1317, 1262, 1070, 999, 848. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.34 (s, 1H, Ar), 7.48 (s, 1H, Ar), 7.54 (td, 1H, $J = 8.6, 1.9$, Ar), 7.55 (t, 1H, $J = 7.6$ Hz, Ar), 7.72 (dd, 1H, $J = 13.8, 8.0$ Hz, Ar), 8.03 (dd, 2H, $J = 15.7, 8.6$ Hz, Ar), 8.33 (d, 2H, $J = 8.5$ Hz, Ar), 8.38 (d, 2H, $J = 8.4$ Hz, Ar), 12.9 (s, 1H, NH). HR-ESI-MS: m/z 384.2288 (M^+).

2-(5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazol-2-yl)phenol (16)

Pale yellow powder, yield: 0.081 g (81%), m.p.: 375.7 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3235, 1612, 1317, 1256, 1155, 1062. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.18 – 7.05 (m, 2H, Ar), 7.34 (s, 1H, Ar), 7.56 – 7.42 (m, 2H, Ar), 7.97 (dt, 1H, $J = 10.1, 5.1$ Hz, Ar), 8.26 (d, 2H, $J = 8.5$ Hz, Ar), 8.38 (d, 2H, $J = 8.5$ Hz, Ar), 10.36 (s, 1H, OH), 12.89 (s, 1H, NH). HR-ESI-MS: m/z 382.2325 (M^+).

3-(5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazol-2-yl)phenol (17)

Pale yellow powder, yield: 0.082 g (82%); m.p.: 369.9 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3236, 1610, 1315, 1262, 1069, 1008. ^1H NMR (500 MHz, DMSO) δ : 2.33 (s, 6H, CH_3 -5,6-benzimidazole), 7.06 (d, 1H, $J = 6.6$ Hz, Ar), 7.40 (s, 2H, Ar), 7.45 (t, 1H, $J = 7.8$ Hz, Ar), 7.54 (s, 1H, Ar), 7.59 (d, 1H, $J = 7.5$ Hz, Ar), 8.25 (d, 2H, $J = 8.3$ Hz, Ar), 8.35 (d, 2H, $J = 8.3$ Hz, Ar), 10.04 (s, 1H, OH). HR-ESI-MS: m/z 382.1843 (M^+).

2-(3,4-dimethoxyphenyl)-5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazole (18)

Pale yellow powder, yield: 0.076 g (76%); m.p.: 293.4 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3255, 1611, 1315, 1275, 1106, 1025. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 3.88, 3.92 (s, 6H, OCH_3 -3'',4''-Ar), 7.20 (d, 1H, $J = 8.5$ Hz, Ar), 7.39 (s, 2H, Ar), 7.65 (d, 1H, $J = 1.9$ Hz, Ar), 7.76 (dd, 1H, $J = 8.4, 2.0$ Hz, Ar), 8.28 (d, 2H, $J = 8.5$ Hz, Ar), 8.36 (d, 2H, $J = 8.5$ Hz, Ar), 12.87 (s, 1H, NH). HR-ESI-MS: m/z 426.2690 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(4-nitrophenyl)-1,3,4-oxadiazole (19)

Pale yellow powder, yield: 0.076 g (76%); m.p.: 361.2 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3302, 1612, 1523, 1340, 1264, 1108, 1082. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.35 (s, 1H, Ar), 7.49 (s, 1H, Ar), 8.33 (d, 2H, $J = 8.4$ Hz, Ar), 8.40 (d, 2H, $J = 8.4$ Hz, Ar), 8.45, 8.48 (d, 4H, $J = 8.9$ Hz, Ar), 12.90 (s, 1H, NH). HR-ESI-MS: m/z 411.2255 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(4-fluorophenyl)-1,3,4-oxadiazole (20)

Pale yellow powder, yield: 0.083 g (83%); m.p.: 372.7 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3292, 1610, 1318, 1264, 1164, 1002, 845. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.34 (s, 1H, Ar), 7.49 (d, 2H, $J = 9.0$ Hz, Ar), 7.54 (d, 2H, $J = 9.0$ Hz, Ar), 8.26 (dd, 2H, $J = 8.8, 5.4$ Hz, Ar), 8.30 (d, 2H, $J = 8.5$ Hz, Ar), 8.38 (d, 2H, $J = 8.5$ Hz, Ar), 12.90 (s, 1H, NH). HR-ESI-MS: m/z 384.2288 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(4-methoxyphenyl)-1,3,4-oxadiazole (21)

Pale yellow powder, yield: 0.077 g (77%); m.p.: 342 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3244, 1614, 1311, 1263, 1174, 1033. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 3.89 (s, 3H, OCH_3 -4''-Ar), 7.20 (d, 2H, $J = 8.8$ Hz, Ar), 7.34 (s, 1H, Ar), 7.48 (s, 1H, Ar), 8.12 (d, 2H, $J = 8.8$ Hz, Ar), 8.28 (d, 2H, $J = 8.4$ Hz, Ar), 8.37 (d, 2H, $J = 8.5$ Hz, Ar), 12.89 (s, 1H, NH). HR-ESI-MS: m/z 396.2500 (M^+).

2-(4-chlorophenyl)-5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazole (22)

Pale yellow powder, yield: 0.075 g (75%); m.p.: 369.7 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3280, 1611, 1317, 1264, 1093, 1016, 844. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 7.35 (s, 1H, Ar), 7.48 (s, 1H, Ar), 7.74 (d, 2H, $J = 8.5$ Hz, Ar), 8.20 (d, 2H, $J = 8.5$ Hz, Ar), 8.30 (d, 2H, $J = 8.4$ Hz, Ar), 8.37 (d, 2H, $J = 8.4$ Hz, Ar), 12.92 (s, 1H, NH). HR-ESI-MS: m/z 400.2004 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(pyridin-4-yl)-1,3,4-oxadiazole (23)

Pale yellow powder, yield: 0.068 g (68%); m.p.: 373.0 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3051, 1612, 1571, 1321, 1272, 1061, 1002. ^1H NMR (500 MHz, DMSO) δ : 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 7.41 (s, 2H, Ar), 8.10 (d, 2H, $J = 5.5$ Hz, Ar), 8.33 (d, 2H, $J = 8.4$ Hz, Ar), 8.39 (d, 2H, $J = 8.4$ Hz, Ar), 8.89 (d, 2H, $J = 4$ Hz, Ar). HR-ESI-MS: m/z 367.1948 (M^+).

2-(3-chlorophenyl)-5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazole (24)

Pale yellow powder, yield: 0.071 g (71%); m.p.: 356.2 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3053, 1614, 1316, 1266, 1032, 1003, 847. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 7.34 (s, 1H, Ar), 7.48 (s, 1H, Ar), 7.69 (t, 1H, $J = 8, 7.5$ Hz, Ar), 7.75 (d, 1H, $J = 8$ Hz, Ar), 8.14 (d, 1H, $J = 7.5$ Hz, Ar), 8.22 (s, 1H, Ar), 8.32 (d, 2H, $J = 8$ Hz, Ar), 8.37 (d, 2H, $J = 8$ Hz, Ar), 12.89 (s, 1H, NH). HR-ESI-MS: m/z 400.2009 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(o-tolyl)-1,3,4-oxadiazole (25)

Pale yellow powder, yield: 0.083 g (83%); m.p.: 348.1 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3179, 1614, 1317, 1287, 1055, 1000. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.36 (s, 6H, CH_3 -5,6-benzimidazole), 2.73 (s, 3H, CH_3 -2''-Ar), 7.34 (s, 1H, Ar), 7.52 – 7.44 (m, 3H, Ar), 7.56 (td, 1H, $J = 7.5, 1.1$ Hz, Ar), 8.13 (d, 1H, $J = 7.6$ Hz, Ar), 8.28 (d, 2H, $J = 8.5$ Hz, Ar), 8.38 (d, 2H, $J = 8.4$ Hz, Ar), 12.88 (s, 1H, NH). HR-ESI-MS: m/z 380.2535 (M^+).

4-(5-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-1,3,4-oxadiazol-2-yl)phenol (26)

Pale yellow powder, yield: 0.079 g (79%); m.p.: 335 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3200, 1609, 1315, 1263, 1079, 1016. ^1H NMR (500 MHz, DMSO) δ : 2.34 (s, 6H, CH_3 -5,6-benzimidazole), 7.00 (d, 2H, $J = 8.5$ Hz, Ar), 7.41 (s, 2H, Ar), 8.01 (d, 2H, $J = 8.5$ Hz, Ar), 8.25 (d, 2H, $J = 8.3$ Hz, Ar), 8.36 (d, 2H, $J = 8.3$ Hz, Ar), 10.40 (s, 1H, Ar). HR-ESI-MS: m/z 382.2328 (M^+).

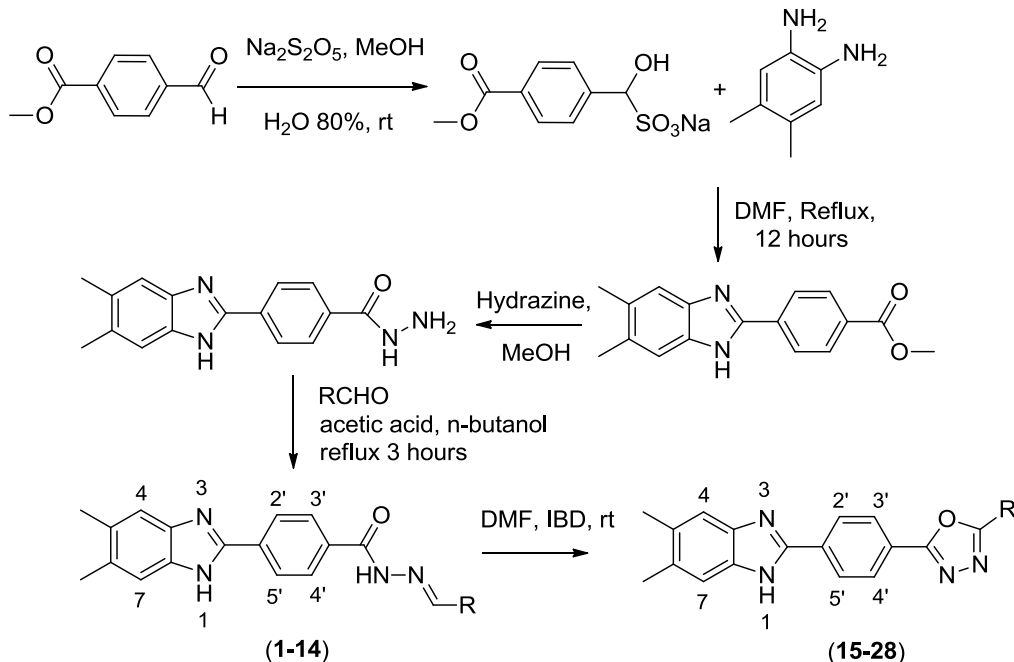
2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(pyridin-3-yl)-1,3,4-oxadiazole (27)

Pale yellow powder, yield: 0.073g (73%); m.p.: 327.9 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3326, 1611, 1565, 1317, 1257, 1054, 999. ^1H NMR (500 MHz, DMSO) δ : 2.34, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 7.36 (m, 2H, Ar), 7.48 (s, 1H, Ar), 8.00 (t, 1H, $J = 4.6$ Hz, Ar), 8.25 (d, 2H, $J = 8.4$ Hz, Ar), 8.37 (d, 2H, $J = 8.4$ Hz, Ar), 12.91 (s, 1H, NH). HR-ESI-MS: m/z 367.1932 (M^+).

2-(4-(5,6-dimethyl-1H-benzo[d]imidazol-2-yl)phenyl)-5-(m-tolyl)-1,3,4-oxadiazole (28)

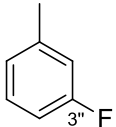
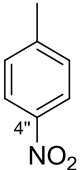
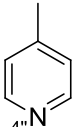
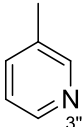
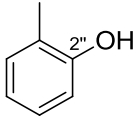
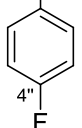
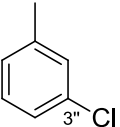
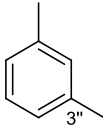
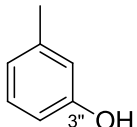
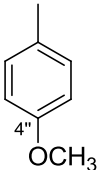
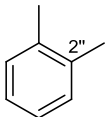
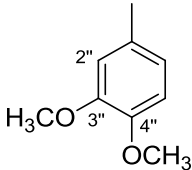
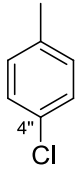
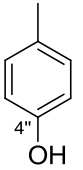
Pale yellow powder, yield: 0.079 g (79%); m.p.: 315.4 °C; IR (KBr) ($\nu_{\max}$, cm^{-1}): 3198, 1612, 1314, 1274, 1080, 999. ^1H NMR (500 MHz, DMSO) δ : 2.33, 2.35 (s, 6H, CH_3 -5,6-benzimidazole), 2.45 (s, 3H, CH_3 -3''-Ar), 7.33 (s, 1H, Ar), 7.48 (d, 2H, $J = 9.3$ Hz, Ar), 7.54 (t, 1H, $J = 7.6$ Hz, Ar), 7.97 (d, 1H, $J = 7.6$ Hz, Ar), 8.00 (s, 1H, Ar), 8.28 (d, 2H, $J = 8.4$ Hz, Ar), 8.37 (d, 2H, $J = 8.4$ Hz, Ar), 12.88 (s, 1H, NH). HR-ESI-MS: m/z 380.2536 (M^+).

The synthesis of the target compounds began with the synthesis of sodium metasulfite adduct according to the literature protocol [5]. The resulting sulfite adduct was refluxed with 4,5-dimethyl-*O*-phenylenediamine in DMF for 6 h to give the arylester substituted benzimidazole. The benzohydrazide of benzimidazole was formed by refluxing arylester of benzimidazole with methanolic hydrazine hydrate (Scheme 1). The synthesis of benzimidazole benzohydrazide Schiff bases (**1-14**) was accomplished by reacting different aldehydes with benzimidazole benzohydrazide in *n*-butanol in the presence of a catalytic amount of acetic acid as shown in Scheme-1. A series of new 2, 5-disubstituted-1,3,4-oxadiazoles (Table 1) have been accomplished in excellent yields by the oxidation of of various aryl aldehydes with one equivalent of iodobenzenediacetate (IBD) in DMF. Compounds **15-28** were synthesized based on the reported procedure.



Scheme 1. Synthesis of oxadiazole derivatives from benzimidazole benzoyl hydrazide

Table 1. Benzimidazole benzohydrazide bearing oxadiazole derivatives

Comp. No.	R	Comp. No.	R	Comp. No.	R	Comp. No.	R
1, 15		5, 19		9, 23		13, 27	
2, 16		6, 20		10, 24		14, 28	
3, 17		7, 21		11, 25			
4, 18		8, 22		12, 26			

The IR spectra of the synthesized compounds exhibited characteristic absorption bands at $1600 - 1700\text{ cm}^{-1}$ and $3100 - 3300\text{ cm}^{-1}$ due to carbonyl or $\text{C}=\text{N}$; and NH group, respectively. The ^1H NMR spectra of compounds **1-14** showed two singlets due at $\text{N}=\text{CH}$ and NH , respectively. The structure of all compounds was confirmed by their spectral data (IR, ^1H NMR, LCMS) and melting point. The characterization of products **15-28** was based upon a careful comparison of their IR and ^1H NMR spectra with those of **1-14**. IR spectra of **15-28** were found to be transparent in the region of NH stretch and CO stretch. In ^1H NMR spectra of **15-28** the disappearance of their singlet due to $\text{N}=\text{CH}$ and NH proton confirms the oxidation of **1-14** into **15-28**.

Conclusion

A series of new 2,5-disubstituted-1,3,4-oxadiazoles derivatives of benzimidazole (**15-28**) were synthesized in good yield and characterized by ^1H NMR, IR, MS spectroscopic methods and melting point. A further study to acquire information concerning the pharmacological activity is in progress.

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