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Synthesis, Characterization, and Antimicrobial Activity of New Bis-1,2,3-triazol-*H*-yl-substituted 2-Arylbenzimidazoles[1]

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Abstract—New bis-1,2,3-triazol-*H*-yl-substituted 2-aryl benzimidazoles **VIa–VIp** were synthesized from *O*- and *N*-bis-propargyl substituted 2-arylbenzimidazoles using "click chemistry." The newly synthesized compounds were characterized by IR, NMR, and mass spectra. These compounds were screened for their activity against bacterial and fungal organisms.

Keywords: antimicrobial activity, benzimidazole, propargyl bromidea azide, click reaction

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INTRODUCTION

Benzimidazoles constitute an important and interesting class of heterocyclic pharmacophores in drug production and medicinal field. Benzimidazole derivatives possess diverse pharmacological and biological activities, of which the most potent are antimicrobial [1], antiviral [2], antiulcer [3], antihypertensive [4], antidiabetic [5], antiinflammatory [6], and anticancer [7]. The potency of these clinically useful drugs in treatment of microbial infections and other activities encouraged the development of some more potent and significant compounds.

So, benzimidazoles being remarkably effective compounds, extensive biochemical and pharmacological studies have confirmed that these molecules are effective against various strains of microorganisms. Some marketed drugs containing a benzimidazole ring are Omeprazole, Albendazole and Candesartan (Scheme 1).

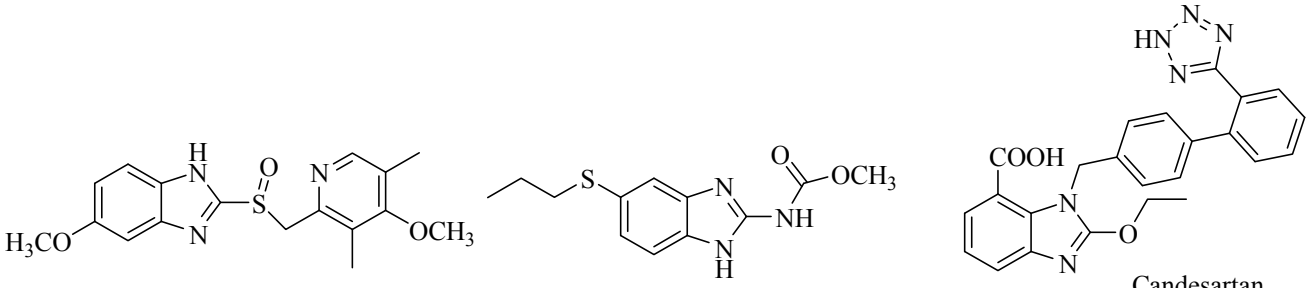
In view of the above, it is proposed that the triazole-containing benzimidazoles form a good pharmacophore. The present paper reports on the synthesis by using "click chemistry" [8], characterization and biological activity of new bis-1,2,3-triazol-*H*-yl-substituted benzimidazole derivatives. Traditionally, the construction of 1,2,3-triazole ring via Cu(I)-catalyzed 1,3-cycloaddition of an azide to a terminal alkyne generally involves the use of a mixture of $CuSO_4 \cdot 5H_2O$ and sodium ascorbate as a precatalyst system, which generates the Cu(I) species in situ in the reaction mixture.

RESULTS AND DISCUSSION

Chemistry. Substituted 2-aryl benzimidazole **IIIa** was synthesized from **Ia** and **II** using $CoCl_2 \cdot 6H_2O$ as an efficient catalyst [9] in good yield about 80%. *O*- and *N*-bis-propargylation to **IVa** was carried out with known general procedure [10] and confirmed by ^{1}H NMR. The *O*- and *N*-bis-propargyl 2-aryl-substituted benzimidazole **IVa** with azide **Va** [11] was converted to bistriazolyl-substituted 2-arylbenzimidazole derivative **VIa** (Scheme 2) via a "click reaction" with 10 mol % of sodium ascorbate and 10 mol % $CuSO_4 \cdot 5H_2O$ as catalysts in good yields about 73–83%. The structure of compound **VIa** was confirmed by using ^{1}H NMR, ^{13}C NMR, FTIR, mass spectra, and elemental analysis. It was further confirmed by comparing the ^{1}H NMR spectrum with that of compound **IVa**. Acetylene peaks of compound **IVa** appeared at δ, ppm: 2.50 s (1H), 2.57 s (1H), and these peaks disappeared and new peaks appeared at δ, ppm: 8.20 s (1H), 8.26 s (1H) in **VIa** due to the formation of triazole rings. All compounds **VIa**–**VIp** were also synthesized by similar procedure and confirmed by the above experimental analyses.

[1] The text was submitted by the authors in English.

Scheme 1.



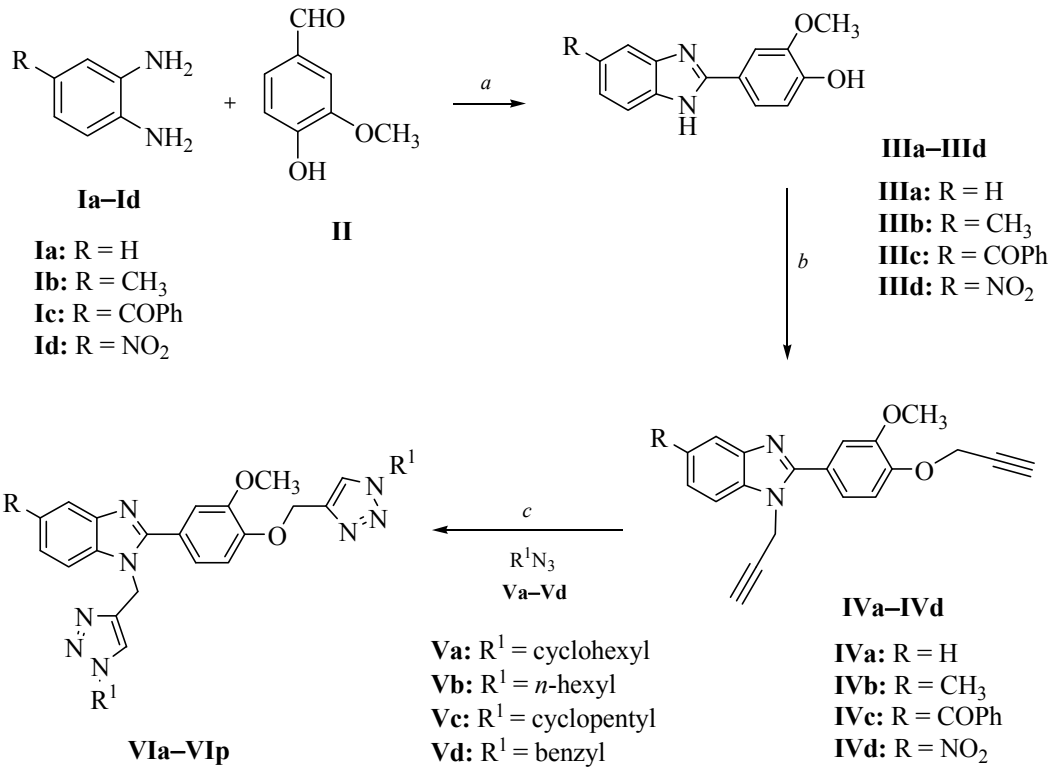
Antibacterial activity. The antibacterial results of Benzimidazole derivatives **VIa**–**VIp** showed moderate to good antibacterial activity against gram-positive and gram-negative bacteria (see table) among them compound **VIg** (R = CH_3, R^1 = cyclopentyl) show excellent activity and **VIb**, **VIe**, **VIh**, and **VIj–VIo** show good activity and the remaining compounds of the series show weak activity against both gram-positive and gram-negative bacteria at a concentration of 10 μg/mL.

All compounds **VIa**–**VIp** were evaluated for anti-fungal activity against *Asperigillus niger* and they showed little activity against the fungal organisms at 50 μg/mL.

Antibacterial activity

Compound	Zone of inhibition (mm)			
	gram-negative bacteria		gram-positive bacteria	
	E. coli	*K. pneumonia*	*S. aureus*	*B. subtilis*
VIa	08	09	09	10
VIb	11	14	12	14
VIc	08	10	10	11
VId	09	12	07	08
VIe	10	13	11	12
VIf	09	09	10	09
VIg	16	23	16	22
VIh	10	09	12	11
VIi	07	06	08	07
VIj	11	12	12	12
VIk	14	20	14	15
VIl	13	18	13	17
VIm	10	17	11	14
VIn	15	21	14	15
VIo	11	14	12	13
VIp	09	12	10	11
Gentamycin	15	22	15	20

Scheme 2. Synthesis of bistriazolyl-substituted 2-arylbenzimidazole derivatives **VIa–VIp**



VIa: R = H, R^1 = cyclohexyl, **VIb:** R = H, R^1 = *n*-hexyl,
VIc: R = H, R^1 = cyclopentyl, **VId:** R = H, R^1 = benzyl,
VIe: R = CH_3, R^1 = cyclohexyl, **VIf:** R = CH_3, R^1 = *n*-hexyl,
VIg: R = CH_3, R^1 = cyclopentyl, **VIh:** R = CH_3, R^1 = benzyl,
VIi: R = COPh, R^1 = cyclohexyl, **VIj:** R = COPh, R^1 = *n*-hexyl,
VIk: R = COPh, R^1 = cyclopentyl, **VIl:** R= COPh, R^1= benzyl,
VIm: R = NO_2, R^1 = cyclohexyl, **VIn:** R = NO_2, R^1 = *n*-hexyl,
VIo: R = NO_2, R^1 = cyclopentyl, **VIp:** R = NO_2, R^1 = benzyl.

(*a*) $CoCl_2 \cdot 6H_2O$, acetonitrile, RT, 4–6 h, (*b*) propargyl bromide, K_2CO_3, DMF, RT, 5–6 h, (*c*) $CuSO_4 \cdot 5H_2O$, sodium ascorbate, DMF, RT, 14–16 h.

EXPERIMENTAL

Materials and methods. All reagents and solvents used were of analytical grade, purchased from Aldrich and SD fine-chem-limited and were used without further purification. The purity of synthesized compounds was checked by TLC on silica gel GF254 plates using UV/ Iodine as visualizing agents. Melting points have been measured in open capillaries using the electrical melting point apparatus and are reported uncorrected. Infrared spectra were recorded on a Fourier Transform Infra Red (FTIR) Perkin–Elmer spectrophotometer using potassium bromide optics, Tensor 27 model spectrophotometer, stretching vibration frequencies are given in cm^{-1}. ^1H and ^{13}C NMR spectra were recorded on a Bruker Bio-spinavance-III (400 MHz) spectrometer using TMS as an internal reference and chemical shifts (δ values) are given in ppm. Mass spectra were recorded on Quatro LC micromass (Waters Manchester, UK) (70 eV) mass spectrometer.

General procedure for the bispropargylation of substituted 2-arylbenzimidazoles (IVa–IVd). The mixture of benzimidazoles **IIIa–IIId** (4.16 mmol) and potassium carbonate (16.64 mmol) in dimethyl-

formamide was magnetically stirred for 10–15 min at room temperature under nitrogen atmosphere, to that propargyl bromide (8.33 mmol) was added dropwise and the mixture was stirred at RT for 5–6 h. The progress of the reaction was monitored by TLC. After the completion of the reaction the reaction mixture was three times extracted with ethyl acetate, the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, concentrated under reduced pressure, and purified by column chromatography on silica gel. The yields of the compounds were 80-85%.

2-[3-Methoxy-4-(prop-2-yn-1-yloxy)phenyl]-1-(prop-2-yn-1-yl)-1*H*-benzo[*d*]imidazole (IVa). Reaction time 5 h, yield 95%, mp 158–160°C. ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 2.50 t (*J* = 2.51, 1H), 2.57 t (*J* = 2.25, 1H), 3.97 s (3H), 4.86 d (*J* = 2.51, 2H), 4.95 d (*J* = 2.25, 2H), 7.20 d (1H), 7.35 m (2H), 7.43 d (1H), 7.48 s (1H), 7.55 d (1H), 7.82 d (1H).

2-[3-Methoxy-4-(prop-2-yn-1-yloxy)phenyl]-5-methyl-1-(prop-2-yn-1-yl)-1*H*-benzo[*d*]imidazole (IVb). Reaction time 5 h, yield 91%, mp 160–162°C. ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 2.46 t (*J* = 2.51, 1H), 2.56 t (*J* = 2.25, 1H), 2.72 s (3H), 3.98 s (3H), 4.85 d (*J* = 2.51, 2H), 4.91 d (*J* = 2.25, 2H), 7.13–7.28 m (3H), 7.36 d (*J* = 8.28, 1H), 7.41 d (*J* = 8.28, 1H), 7.44 s (1H). ^{13}C NMR(400 MHz, $CDCl_3$), δ, ppm: 16.8, 34.8, 56.0, 56.7, 73.7, 76.3, 77.8, 78.1, 107.3, 112.9, 113.9, 121.9, 123.0, 123.2, 123.5, 130.0, 135.0, 142.1, 148.1, 149.7, 153.3.

2-[3-Methoxy-4-(prop-2-yn-1-yloxy)phenyl]-1-(prop-2-yn-1-yl)-1*H*-benzo[*d*]imidazol-5-yl)(phenyl) methanone (IVc). Reaction time 6 h, Yield 92%, mp 162–164°C. ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 2.53 t (*J* = 2.51, 1H), 2.58 t (*J* = 2.25, 1H), 3.99 s (3H), 4.88 d (*J* = 2.51, 2H), 5.01 d (*J* = 2.25, 2H), 7.22 d (*J* = 8.28, 1H), 7.47–7.54 m (4H), 7.60–7.64 m (1H), 7.79 d (*J* = 8.28, 1H), 7.86 m (3H), 8.12 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$), δ, ppm: 35.1, 56.1, 56.6, 74.5, 76.4, 77.2, 77.9, 112.5, 112.7, 113.7, 119.1, 121.9, 122.5, 125.9, 128.2, 130.0, 132.1, 132.4, 135.3, 138.3, 146.1, 148.7, 149.9, 155.8, 196.5.

2-[3-Methoxy-4-(prop-2-yn-1-yloxy)phenyl]-5-nitro-1-(prop-2-yn-1-yl)-1*H*-benzo[*d*]imidazole (IVd). Reaction time 6 h, yield 94%, mp 168–170°C. ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 2.57 t (*J* = 2.51, 1H), 2.60 t (*J* = 2.25, 1H), 3.99 s (3H), 4.88 d (*J* = 2.51, 2H), 5.02 d (*J* = 2.25, 2H), 7.23 d (*J* = 8.53, 1H), 7.46 m (2H), 7.86 d (*J* = 9.03,1H), 8.29 m (1H), 8.51 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$), δ, ppm: 35.41, 56.1, 56.6, 74.8, 75.1, 76.5, 77.8, 106.8, 109.9, 112.7, 113.7, 116.4, 118.9, 119.8, 121.9, 122.0, 134.9, 139.5, 142.3, 143.6, 144.2, 147.3, 149.0, 149.1, 150.0, 156.5, 157.7.

General procedure for synthesis of azides Va–Vd. A mixture of different alkyl bromides (2.99 mmol) and sodium azide (7.48 mmol) in DMF was stirred at 80°C for 18h under nitrogen atmosphere. The progress of the reaction was monitored by TLC. After the completion of the reaction the product was 3 times extracted into ethyl acetate, the combined organic layers were washed with brine and dried over anhydrous Na_2SO_4 and concentrated under a reduced pressure. No purification was required.

General procedure of preparation of bis-1,2,3-triazol-1*H*-yl-substituted benzimidazoles VIa–VIp. To a mixture of bispropargylated compound **IVa–IVd** (0.316 mmol) and azides **Va–Vd** (0.696 mmol) in DMF was added 10 mol % sodium ascorbate and 10 mol % $CuSO_4 \cdot 5H_2O$ in water. The reaction mixture was stirred for 14–16 h at room temperature. The progress of the reaction was monitored by TLC. After the completionof the reaction the product was three times extracted into ethyl acetate, the combined organic layers were washed with brine, dried over anhydrous Na_2SO_4 and concentrated under a reduced pressure and purified by column chromatography on silica gel. The yields obtained were 73–83%.

2-{4-[(1-Cyclohexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl-1-(1-cyclohexyl-1*H*-1,2,3-triazol-4-yl)methyl}-1*H*-benzo[*d*]imidazole (VIa). Reaction time 14 h, yield 81%, mp >300°C. IR (KBr, cm^{-1}): 1606 (C=N), 1257 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.19–1.34 m (4H), 1.35–1.52 m (4H), 1.64–1.80 m (4H), 1.83–1.96 m (4H), 2.16–2.28 m (4H), 3.93 s (3H), 4.31–4.52 m (2H), 5.35 s (2H), 5.54 s (2H), 7.20 d (*J* = 7.78, 1H), 7.27–7.37 m (4H), 7.45 d (2H), 7.68 s (1H), 7.84 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 25.1, 27.2, 28.0, 32.1, 41.1, 54.5, 56.1, 60.2, 63.0, 112.5, 113.5, 113.6, 119.1, 120.2, 122.0, 122.5, 125.9, 126.3, 142.9, 143.0, 143.5, 149.5, 149.7. ESI-MASS: *m/z* at 567 $[M + H]^+$. Calculated, %: C 67.82; H 6.75; N 19.77. $C_{32}H_{38}N_8O_2$. Found, %: C 67.84; H 6.78; N 19.76.

2-{4-[(1-Hexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-hexyl-1*H*-1,2,3-triazol-4-yl)-methyl]-1*H*-benzo[*d*]imidazole (VIb). Reaction time 14 h, yield 83%, mp >300°C. IR (KBr, cm^{-1}): 1606 (C=N), 1254 (N=N). ^{13}C NMR (400 MHz, $CDCl_3$):

13.8, 22.3, 26.0, 29.6, 30.1, 31.1, 41.2, 50.4, 50.5, 56.1, 63.1, 110.03, 110.05, 113.6, 119.8, 121.6, 121.9, 122.7,123.0, 143.0, 143.7, 149.1, 149.7. ESI-MASS: *m/z* at 571 $[M + H]^+$. Calculated, %: C 67.34; H 7.41; N 19.63. $C_{32}H_{42}N_8O_2$. Found, %: C 67.38; H 7.43; N 19.62.

2-{4-[(1-Cyclopentyl-1*H*-1,2,3-triazol-4-yl)methoxy-3-methoxyphenyl}-1-[(1-cyclopentyl-1*H*-1,2,3-triazol-4-yl)methyl]-1*H*-benzo[*d*]imidazole (VIc). Reaction time 15 h, yield 79%, mp >300°C. IR (KBr, cm^{-1}): 1608 (C=N), 1244 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.67–1.79 m (4H), 1.83–1.90 m (4H), 1.95–2.08 m (4H), 2.17–2.30 m (4H), 3.91 s (3H), 4.48–4.96 m (2H), 5.34 s (2H), 5.54 s (2H), 7.19 d (*J* = 8.28 Hz, 1H), 7.27-7.34 m (4H), 7.40 d (*J* = 8.53 Hz, 1H),7.42(s, 1H), 7.72(s, 1H), 7.82 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 23.9, 29.6, 33.3, 41.2, 56.1, 61.9, 62.9, 63.1,110.0, 113.0, 113.6,119.8, 120.4, 121.5, 121.9, 122.7, 123.0, 135.8, 143.0, 143.4, 143.6, 149.2, 149.6, 153.5. ESI-MASS: *m/z* at 539 $[M + H]^+$. Calculated, %: C 66.89; H 6.35; N 20.80. $C_{30}H_{34}N_8O_2$. Found, %: C 66.92; H 6.39; N 20.79.

2-{4-[(1-Benzyl-1*H*-1,2,3-triazol-4-yl)methoxy)-3-methoxyphenyl}-1-[(1-benzyl-1*H*-1,2,3-triazol-4-yl)methyl]-1-1*H*-benzo[*d*]imidazole (VId). Reaction time 15 h, yield 76%, mp >300°C. IR (KBr, cm^{-1}): 1605 (C=N), 1254 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 3.75 s (3H), 5.20 s (2H), 5.30 s (2H), 5.40 s (2H), 5.51 s (2H), 6.55–6.66 m (2H), 7.02 d (*J* = 8.03 Hz, 1H), 7.15–7.33 m (5H), 7.30–7.42 m (5H), 7.55–7.62 d (*J* = 11.54 Hz, 1H), 7.87–7.92 d (*J* = 9.03 Hz, 1H), 8.20 s (1H), 8.26 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 41.1, 54.2, 54.3, 56.1, 63.1, 110.0, 112.9, 113.8, 119.5, 120.2, 121.2, 122.1, 123.3, 127.1, 128.0, 129.6, 134.1, 143.2, 143.7, 149.5, 149.7. ESI-MASS: *m/z* at 583 $[M + H]^+$. Calculated, %: C 70.08; H 5.18; N 19.23. $C_{34}H_{30}N_8O_2$. Found, %: C 70.11; H 5.19; N 19.21.

2-{4-[(1-Cyclohexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-cyclohexyl-1*H*-1,2,3-triazol-4-yl)methyl]-5-methyl-1*H*-benzo[*d*]imidazole (VIe). Reaction time 14 h, yield 78.5%, mp >300°C. IR (KBr, cm^{-1}): 1606(C=N), 1242 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.18–1.33 m (4H), 1.34–1.51 m (4H), 1.60–1.79 m (4H), 1.86–1.972 m (4H), 2.09–2.25 m (4H), 2.72 s (3H), 3.89 s (3H), 4.32–4.48 m (2H), 5.36 s (2H), 5.50 s (2H), 7.11 d (*J* = 6.77 Hz, 1H), 7.15–7.19 d (*J* = 8.28 Hz, 1H), 7.20 d (*J* = 4.76 Hz 1H), 7.23–7.29 m (3H), 7.37 s (1H), 7.66 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 16.8, 24.9, 25.0, 29.6, 33.5, 41.1, 56.0, 60.2, 60.3, 63.2, 107.4, 113.1, 113.6, 119.5, 120.6, 122.1, 122.9, 123.2, 129.9, 135.3, 142.2, 143.3, 143.5, 149.0, 149.5, 152.8. ESI-MASS: *m/z* at 581 $[M + H]^+$. Calculated, %: C 68.25; H 6.93; N 19.29. $C_{33}H_{40}N_8O_2$. Found, %: C 68.28; H 6.95; N 19.27.

2-{4-[1-Hexyl-1*H*-1,2,3-triazol-4-yl)methoxy]3-methoxyphenyl}-1-[1-hexyl-1*H*-1,2,3-triazol-4-yl)-methyl]5-methyl-1*H*-benzo[*d*]imidazole (VIf). Reaction time 14 h, yield 79%, mp >300°C. IR (KBr, cm^{-1}): 1607 (C=N), 1242 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 0.78–0.92 m (6H), 1.18–1.40 m (8H), 1.55–1.71 m (4H), 1.75–1.94 m (4H), 2.76 s (3H), 3.93 s (3H), 4.22–4.4 m (4H), 5.36 s (2H), 5.57 s (2H), 7.09–7.26 m (6H), 7.42 s (1H), 7.64 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 13.8, 16.9, 22.3, 26.0, 30.0, 31.1, 41.1, 50.5, 50.56, 56.1, 63.1, 107.6, 113.1, 113.7, 121.7, 122.1, 122.7, 122.9, 123.1, 123.4, 129.7, 135.1, 141.8, 143.7, 149.1, 149.7, 152.8. ESI-MASS: *m/z* at 585 $[M + H]^+$. Calculated, %: C 67.78; H 7.57; N 19.16. $C_{33}H_{44}N_8O_2$. Found, %: C 67.81; H 7.59; N 19.19.

2-{4-[(1-Cyclopentyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-cyclopentyl-1*H*-1,2,3-triazol-4-yl)methyl]-5-methyl-1*H*-benzo[*d*]imidazole (VIg). Reaction time 15 h, yield 78%, mp >300°C. IR (KBr, cm^{-1}): 1605 (C=N), 1240 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.67–1.79 m (4H), 1.81–2.10 m (8H), 2.10–2.30 m (4H), 2.74 s (3H), 3.91 s (3H), 4.80–4.95 m (2H), 5.34 s (2H), 5.50 s (2H), 7.09–7.25 m (5H), 7.28 s (1H), 7.40 s (1H), 7.66 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 14.0, 25.1, 29.1, 41.1, 54.1, 56.0, 61.1, 63.1, 110.5, 113.5, 113.6, 119.2, 120.3, 121.5, 123, 135.1, 136.0, 138.1, 143.1, 143.3, 143.7, 149.2, 149.6. ESI-MASS: *m/z* at 553 $[M + H]^+$. Calculated, %: C 67.37, H 6.55, N 20.27. $C_{31}H_{36}N_8O_2$. Found, %: C 67.41, H 6.60, N 20.29.

2-{4-[(1-Benzyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-benzyl-1*H*-1,2,3-triazol-4-yl)methyl]-5-methyl-1*H*-benzo[d]imidazole (VIh). Reaction time 15 h, yield 78.6%, mp >300°C. IR (KBr, cm^{-1}): 1606 (C=N), 1243 (N=N). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 2.70 s (3H), 3.76 s (3H), 5.30 s (2H), 5.46 s (2H), 5.46 s (2H), 5.50 s (2H), 7.09 d (*J* = 8.28 Hz, 2H), 7.16–7.23 m (5H), 7.26–7.30 m (3H), 7.32–7.38 m (6H), 7.56 s (2H), 8.12 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 31.9, 41.0, 54.2, 55.8, 55.9, 63.1, 107.4, 113.0, 114.0, 121.7, 122.1, 122.8, 123.1, 123.4, 127.8, 128.1, 128.8, 129.1, 130.0, 134.3, 135.2, 142.3,

144.2, 144.4,148.9, 149.6, 152.7. ESI-MASS: *m/z* at 597 $[M + H]^+$. Calculated, %: C 70.45; H 5.40; N 18.77. $C_{35}H_{32}N_8O_2$. Found, %: C 70.48; H 5.43; N 18.75.

{2-(4-[(1-Cyclohexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl)-1-[(1-cyclohexyl-1*H*-1,2,3-triazol-4-yl)methyl]-1*H*-benzo[*d*]imidazol-5-yl}-(phenyl)methanone (VIi). Reaction time 15 h, yield 76%, mp >300°C. IR (KBr, cm^{-1}): 1608 (C=N), 1263 (N=N), 1649 (C=O). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.13–2.29 m (20H), 3.95 s (3H), 4.43–4.49 m (2H), 5.30 s (2H), 5.69 s (2H), 7.17 m (1H), 7.45–7.54 m (3H), 7.56–7.63 m (1H), 7.69 s (1H), 7.8–7.92 m (5H), 8.2 s (1H), 7.69 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 14.1, 22.6, 25.1, 29.6, 41.3, 56.2, 60.2, 60.4, 63.1, 110.1, 113.1, 113.6, 119.6, 118.8, 120.7, 122.0, 123.2, 125.7, 128.2, 130.0, 132.1, 132.5, 138.2, 142.6, 143.1, 149.6, 149.7, 196.5. ESI-MASS: *m/z* at 672 $[M + H]^+$. Calculated, %: C 69.83; H 6.30; N 16.70. $C_{39}H_{42}N_8O_3$. Found, %: C 69.87; H 6.35; N 16.67.

{2-(4-[(1-Hexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl)-1-[(1-hexyl-1H-1,2,3-triazol-4-yl)-methyl]-1*H*-benzo[*d*]imidazol-5-yl}(phenyl)methanone (VIj). Reaction time 15 h, yield 81%, mp >300°C. IR (KBr, cm^{-1}): 1609 (C=N), 1263 (N=N), 1645 (C=O). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 0.80–0.91 m (6H), 1.20-1.95 m (16H), 3.94 s (3H), 4.30–4.39 m (4H), 5.38 s (2H), 5.58 s (2H), 7.20 d (J = 8.53 Hz, 1H), 7.30–7.34 d (J = 8.03 Hz, 1H), 7.41 s (1H), 7.50–7.61 m (2H), 7.66 s (1H), 7.70–7.91 m (5H), 7.98 s (1H), 8.24 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 13.9, 22.3, 26.0, 26.1, 30.1, 31.1, 41.3, 50.4, 50.6, 56.2, 63.1, 110.0, 112.7, 113.8, 119.5, 119.9, 120.6, 122.0, 122.4, 122.6, 124.9, 128.1, 128.2, 129.9, 132.1, 132.6, 138.2, 142.2, 143.0, 143.6, 147.2, 149.5, 196.5. ESI-MASS: *m/z* at 676 $[M + H]^+$. Calculated, %: C 69.41; H 6.86; N 16.60. $C_{39}H_{46}N_8O_3$. Found, %: C 69.43; H 6.89; N 16.58.

{2-(4-[(1-Cyclopentyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl)-1-[(1-cyclopentyl-1*H*-1,2,3-triazol-4-yl)methyl]-1*H*-benzo[d]imidazol-5-yl}-(phenyl)methanone (VIk). Reaction time 16 h, yield 78%, mp >300°C. IR (KBr, cm^{-1}): 1608 (C=N), 1261 (N=N), 1648 (C=O). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.76 m (4H), 1.88 m (4H), 2.02 m (4H), 2.24 m (4H), 3.91 s (3H), 4.90 m (2H), 5.31 s (2H), 5.50 s (2H), 7.23 d (J = 8.03 Hz, 1H), 7.34 s (1H), 7.41(s, 1H), 7.45–7.53 m (3H), 7.57–7.62 m (2H), 7.69 s (1H), 7.76–7.92 m (3H), 8.01 s (1H), 8.24 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 22.6, 29.6, 33.3, 41.2, 56.2, 62.0, 62.1, 63.1, 110.2, 112.8, 113.2, 119.5, 121.1, 121.6, 122.1, 122.3, 123.1, 123.5, 125.1, 125.4, 128.2, 130.0, 132.0, 132.1, 138.1, 138.2, 149.7, 196.5. ESI-MASS: *m/z* at 644 $[M + H]^+$. Calculated, %: C 69.14; H 5.95; N 17.43. $C_{37}H_{38}N_8O_3$. Found, %: C 69.16; H 5.98; N 17.40.

2-(4-[(1-Benzyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl)-1-[(1-benzyl-1*H*-1,2,3-triazol-4-yl)methyl]-1*H*-benzo[*d*]imidazol-5-yl}(phenyl)-methanone (VIl). Reaction time 16 h, yield 79.9%, mp >300°C. IR (KBr, cm^{-1}): 1610 (C=N), 1250 (N=N), 1645(C=O). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 3.83 s (3H), 5.32 s (2H), 5.50 s (2H), 5.53 s (2H), 5.55 s (2H), 7.16 m (1H), 7.20–7.24 m (2H), 7.31–7.39 m (8H), 7.44–7.51 m (4H), 7.55–7.61 m (2H), 7.73–7.90 m (4H), 7.97 s (1H), 8.22 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 41.1, 54.2, 56.5, 57.0, 63.5, 110.0, 112.9, 113.1, 119.1, 120.1, 121.1, 122.0,122.3, 123.4, 125.5,125.8, 125.9, 126.2,127.0, 128.1, 129.0, 130.1, 131.0, 135.1, 143.1, 143.2, 149.1, 196.3. ESI-MASS: *m/z* at 687 $[M + H]^+$. Calculated, %: C 71.80; H 4.99; N 16.33. $C_{41}H_{34}N_8O_3$. Found, %: C 71.78; H 4.95; N 16.35.

2-{4-[(1-Cyclohexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-cyclohexyl-1*H*-1,2,3-triazol-4-yl)methyl]-5-nitro-1*H*-benzo[*d*]imidazole (VIm). Reaction time 15 h, yield 73.8%, mp >300°C. IR (KBr, cm^{-1}): 1606 (C=N), 1260 (N=N), 1333, 1517 (NO_2). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.19–1.33 m (4H), 1.37–1.52 m (4H), 1.64–1.81 m (4H), 1.87–1.97 m (4H), 2.12–2.25 m (4H), 3.93 s (3H), 4.38–4.50 m (2H), 5.36 s (2H), 5.59 s (2H), 7.34 d (J = 10.29 Hz, 1H), 7.44–5.58 m (2H), 7.68 s (1H), 7.85 d (J = 8.78 Hz, 1H), 8.22 m (1H), 8.35 s (1H), 8.7 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 249, 25.0, 25.1, 33.47, 41.3, 56.2, 60.2, 60.5, 63.0, 106.9, 110.2, 113.0, 113.5, 118.7, 119.6, 120.8, 121.8, 122.1, 122.5, 142.5, 143.0, 143.4, 147.6, 149.7, 149.8, 149.9. ESI-MASS: *m/z* at 612 $[M + H]^+$. Calculated, %: C 62.83; H 6.09; N 20.60. $C_{32}H_{37}N_9O_4$. Found, %: C 62.87; H 6.12; N 20.59.

2-{4-[(1-Hexyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-hexyl-1*H*-1,2,3-triazol-4-yl)-methyl]-5-nitro-1*H*-benzo[*d*]imidazole (VIn). Reaction time 15 h, yield 74.4%, mp >300°C. IR (KBr, cm^{-1}): 1604 (C=N), 1265 (N=N), 1332, 1517 (NO_2). ^1H NMR (400 MHz, $CDCl_3$), δ, ppm: 0.85–0.92 m (6H), 1.21–1.38 m (12H), 1.82–1.95 m (4H), 3.94 s (3H), 4.28–4.40 m (4H), 5.38 s (2H), 5.58 s (2H), 7.23 d (J =

8.28 Hz, 1H), 7.27 s (1H), 7.44–7.52 m (1H), 7.67 s (1H), 7.84 d (J = 8.78 Hz, 1H), 8.20 m (1H), 8.34 s (1H), 8.69 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 13.0, 22.0, 27.1, 29.1, 31.0, 41.1, 50.4, 54.1, 56.1, 63.1, 110.0, 112.5, 113.5, 113.6, 119.1, 121.4, 122.2, 123.0, 124.1, 139.0, 141.5, 142.5, 143.2, 143.7, 149.1,149.6. ESI-MASS: *m/z* at 616 $[M + H]^+$. Calculated, %: C 62.42; H 6.70; N 20.47. $C_{32}H_{41}N_9O_4$. Found, %: C 62.45; H 6.74; N 20.45.

2-{4-[(1-Cyclopentyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-cyclopentyl-1*H*-1,2,3-triazol-4-yl)methyl]-5-nitro-1*H*-benzo[*d*]imidazole (VIo). Reaction time 16 h, yield 71%, mp >300°C. IR (KBr, cm^{-1}): 1606 (C=N), 1263 (N=N), 1331, 1517 (NO_2). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 1.69–1.83 m (4H), 1.84–1.94 m (4H), 1.97–2.12 m (4H), 2.20–2.35 m (4H) 3.94 s (3H), 4.93 m (2H), 5.30 s (2H), 5.59 s (2H), 7.37 s (1H), 7.43–7.64 d (2H), 7.67–7.91 d (2H), 8.24 s (1H), 8.36 s (1H), 8.72 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 24.0, 29.1, 33.0, 51.1, 54.1, 56.0, 63.1, 112.0, 113.5, 113.6, 118.6, 119.1, 120.7, 121.7, 122.5, 123.6, 124.5, 142.6, 143.1, 143.6, 149.1, 149.7. ESI-MASS: *m/z* at 584 $[M + H]^+$. Calculated, %: C 61.74; H 5.69; N 21.59. $C_{30}H_{33}N_9O_4$. Found, %: C 61.75; H 5.71; N 21.58.

2-{4-[(1-Benzyl-1*H*-1,2,3-triazol-4-yl)methoxy]-3-methoxyphenyl}-1-[(1-benzyl-1*H*-1,2,3-triazol-4-yl)-methyl]-5-nitro-1*H*-benzo[*d*]imidazole (VIp). Reaction time 16 h, yield 74.8%, mp >300°C. IR (KBr, cm^{-1}): 1608 (C=N), 1243 (N=N), 1328, 1517 (NO_2). ^{1}H NMR (400 MHz, $CDCl_3$), δ, ppm: 3.82 s (3H), 5.33 s (2H), 5.50 s (2H), 5.53 s (2H), 5.55 s (2H), 7.27–7.33 m (5H), 7.34–7.39 m (8H), 7.44–7.5 m (2H), 7.59 s (1H), 7.59 s (1H), 8.28 s (1H), 8.68 s (1H). ^{13}C NMR (400 MHz, $CDCl_3$): 41.1, 54.2, 56.0, 56.8, 63, 110.2, 112.5, 113.1, 119.1, 120.1, 121.1, 122.3, 123.0, 125.1, 127.0, 128.1, 139.0, 142.7, 143.1, 143.3, 149.1, 149.7. ESI-MS: *m/z* at 628 $[M + H]^+$. Calculated, %: C 65.06; H 4.65; N 20.08. $C_{34}H_{29}N_9O_4$. Found, %: C 65.10; H 4.62; N 20.11.

Antibacterial activity. The antimicrobial activity was determined using disc diffusion method by measuring zone of inhibition in mm. The newly synthesized compounds **VIa**–**VIp** were evaluated *in-vitro* at a concentration of 10 μg/mL for antibacterial activity against Gram-positive bacteria viz., *Staphylococcus aureus and Bacillus subtilis* and Gram-negative bacteria viz., *Escherichia coli* and *Klebsialla pneumonia*. Standard antibacterial drug gentamycin (10 μg/mL) was also tested under similar conditions against these organisms. Each experiment was done in triplicate and the average reading was taken. The results of antibacterial activity are expressed in terms of zone of inhibition and presented in Table 1. Growth inhibition was calculated with reference to positive control. Benzimidazole derivatives **VIa**–**VIp** were dissolved in dimethyl sulfoxide at 10 μg/mL concentration. The inhibition zones were measured in millimeters at the end of an incubation period of 24 h at (35±2)°C. DMSO alone showed no inhibition. The composition of nutrient agar medium was Bacto-tryptone (10 g), yeast extract (5 g), NaCl (10 g), final pH 7.4.

CONCLUSIONS

We synthesized new bis-1,2,3-triazol-*H*-yl-substituted 2-arylbenzimidazoles **VIa**–**VIp** from *O*- and *N*-propargyl-substituted 2-arylbenzimidazoles **IVa**–**IVd** and azides **Va**–**Vd** using "click chemistry." These compounds were screened for antibacterial activity, among all the compounds **VIg** shows excellent activity and **VIb**, **VIe**, **VIh**, **VIj**–**VIo** show good activity against both gram-positive bacteria and gram-negative bacteria at a concentration of 10 μg/mL.

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