Original Article

Synthesis New Benzimidazole Derivatives as Antibacterial

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Abstract

N-substituted alkylbenzimidazole derivatives connected to 1,2,3-triazole through methlene linkers (tb1, tb2, tb3, tb4 and tb5) were prepared and designed with the goal of estimating their anti-organism activity such as anti-bacterial activity. FTIR and NMR spectroscopies were used to analyzed the prepared compounds. The biological potential of these substances was examined for antibacterial activity against tow type of microorganisms, the first [gram-negative (*Escherichia Coli*)] and the second [gram-positive (*Staphylococcus Aureus*)]. Compared with Gram-negative bacteria, all compounds showed a strong effect against Gram-positive bacteria.

Keywords: Benzimidazole, Resistant Bacteria, 1,2,3-Triazole, Antibiotic, Benzimidazolium Salts.

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INTRODUCTION

Because they operate as inhibitors and have a high selectivity ratio, benzimidazoles and its derivatives are highly potent substances. A large number of biochemical and pharmacological investigations have demonstrated the effectiveness of benzimidazole compounds against various bacterial species [1–8]. The benzimidazoles derivatives are important a class of heterocyclic molecules with diverse biological characteristics that have the potential to be bioactive. This particular molecule is a component of vitamin B12 [9]. The ring system with hetero atom is involved in a variety of biological processes, including antioxidant molecules [10–12], antihelminthic [13–15], antiparasitic [16,17], anticonvulsant and antiproliferative [18-21], anti-HIV [22], anti-inflammatory [19–22], antineoplastic [23, 24], antihypertensive [25, 26], and antitrichinellosis [27]. Due to benzimidazoles' enormous significance and wide range of bioactivities, on occasion, efforts have been made to assemble collections of these substances and examine their possible biological activity. Due to its impact on health care, including lengthier hospital stays and increased mortality, antibiotic resistance is a hazard to the general public on a global scale. The availability of effective antibiotic therapies is becoming increasingly constrained due to the rise in hospital- and community-acquired illnesses brought on by bacteria that are multidrug resistant (MDR) [28,29]. There are many drug-resistant Gram-resistant bacterial pathogens, such as the drug methicillin-resistant Staphylococcus aureus (MRSA) and on the other hand, vancomycin-resistant enterococci (VRE) has emerged as a serious clinical problem affecting management. of many community and hospital acquired diseases [30,31]. One of the main risks to the management of respiratory and other infections is the rise in MDR Gram-negative bacteria, such as *Klebsiella pneumoniae Pseudomonas aeruginosa, and Escherichia coli*, together with the dearth of novel medications, pose one of the major and common threats to the therapy of respiratory system and other infections [32]. To deal with these increasingly apparent problems with microorganism's resistance, novel anti-bacterial medication must be developed and new drugs discovered. As a result, in recent years many efforts have been made and researches to find new antibacterial drugs based on benzimidazole [33–37]. Studies [38, 39] have looked into the significance of a protonable chemical moiety in anti-bacterial medications. These have shown that amidine-containing DNA ligands are significantly taken up by bacteria as well as eukaryotic cell nuclei [40]. Additionally, the 1,2,3-triazole's structural characteristics allow it to imitate several functional groups, this supports its widespread usage in the production of antimicrobial drug analogs as a bioisostere [41,42]. For instance, 1,4-disubstituted isomers in five membered ring triazoles compounds are advantageous Z-amide isosteres because the carbon atom at position C-4 in triazole ring system undergo electron deficiency so it can work as an electrophilic center, the C-H bond (in carbon atom at five position) in triazole ring, it acts as a hydrogen bond donor, and the lone pair of azide moiety (N_3) electrons actions as a hydrogen bond acceptor [43]. Testing in vivo for Gram-positive bacteria [44–47] and

Gram-negative bacteria [48] have shown shown the growing significance of benzimidazole and triazole derivatives. Ridinilazole, SMT-19969, a bis-benzimidazole chemical, phase III human clinical trials to treat Clostridium difficile have just begun. So, in addition to conducting research on their antibacterial properties, we developed a range of alkyl benzimidazolium bromide salts in this paper.

EXPERIMENTAL

Sigma-Aldrich and Fluka provided the highest quality analytical grade solvents and compounds, which were all purchased commercially. The Faculty of Science at the University of Kufa used the FT-IR, Bruker ALPHA FT-IR to record the infrared spectra. Using a Bruker spectrometer, researchers from Iran's Shahid Beheshti University obtained NMR spectra in DMSO-d6 (75MHz for ^{13}C NMR, and 300MHz for ^{1}H NMR respectively). Melting points are determined using a device made in the UK called the Electro Thermal Melting Point Apparatus.

Synthesis N-Substituted Benzimidazole [49]

(0.3809 mol) KOH powder and (0.0253 mol) benzimidazole were put into the flask with a circular bottom. The mixture of stating materials was mix with 45.0 mL of (DMSO), and the formed mixture of reactant substances was stirred at 90°C for two hours. 0.0126 mol of alkyl bromide was cautiously added dropwise while being stirred continuously. After full alkyl bromide was added at low temperature, the mixture was continue stirred for 1.5 hours at 40 °C. The flask was taken away. 250 mL of crushed ice should be poured into the solution, and the solution should be quickly stirred for 30 mint. The mixture was then allowed to sit for an hour before being extracted using distilled water and petroleum ether (3X10 mL). The products were cleaned of petroleum ether.

1-Decyl-1H-benzo[d]imidazole (b1): Yield percentage (79 %), FT-IR cm^{-1}: 3064 (C-H$_{aro.}$), 2945 (C-H$_{ali.}$), 2868 (C-H$_{ali.}$), 1622 (C=N), and1247 (C-N). ^{1}H NMR, 0.85 (t, *J* = 6.7 Hz, 3H, CH$_3$), 1.79 (p, *J* = 6.9 Hz, 2H), 1.19-1.27 (m, 14H, 7 x CH$_2$), 1.78 (p, J = 6.9 Hz, 2H), 4.24 (t, *J* = 7.0 Hz, 2H, N-CH$_2$), 8.27 (s, 1H, NCHN), 7.61 -7.24 (m, 4H, Ar-H), ^{13}C NMR, δ 144.36(NCHN), 143.91, 134.22, 122.55, 122.14, 121.74, 119.85, 115.73, 110.70(Ar-C), 44.54(N-CH$_2$), 31.78, 29.87, 29.44, 29.42, 29.19, 29.04, 26.60, 22.59(8-CH$_2$), 14.34(CH$_3$).

1-Dodecyl-1H-benzo[d]imidazole (b2): Yield percentage (79 %), FT-IR cm^{-1}: 3069(C-H$_{aro.}$),2925(C-H$_{ali.}$), 2878(C-H$_{ali.}$), 1658 (C =N),1265 (C-N). ^{1}H NMR, 0.86 (t, *J* = 6.6 Hz, 3H), 1.21-1.28 (m, 16H, 9 x CH$_2$), 1.76 (p, J = 6.8 Hz, 2H), 4.22 (t, *J* = 7.0 Hz, 2H, N-CH$_2$), 8.24 (s, 1H, NCHN), 7.62-7.24 (m, 4H, Ar-H), ^{13}C NMR, δ 144.34(NCHN), 144.04, 134.25, 122.51, 121.69, 119.90, 110.63(Ar-C),44.52(N-CH$_2$), 31.79, 29.89, 29.43, 29.19, 29.05, 26.62, 22.59(10-CH$_2$), 14.32 (CH$_3$).

1-Tetradecyl-1H-benzo[d]imidazole (b3): Yield percentage (86% yield) with the following FT-IR cm^{-1} readings: 3075 (C-Haromatic), 2929 (C-Haliph), 2856 (C-Haliph), 1625 (C=N), and1265 (C-N). ^{1}H NMR, 0.85 (t, J = 6.4 Hz, 3H), 1.22-0.96 (m, 22H, 11x CH2), 1.77 (p, J = 7.0 Hz, 2H), 4.21 (t, J = 7.1 Hz, 2H, N-CH2), 7.65-7.19 (m, 4H, Ar-H), 8.26 (s, 1H, NCHN), 13C NMR, δ 145.31(NCHN), 144.01, 135.35, 123.15, 122.14, 118.89, 111.61(Ar-C), 43.78(N-CH$_2$), 31.81, 29.86, 29.57, 29.54, 29.51, 29.44, 29.42, 29.24, 29.02, 26.59, 22.59(12-CH$_2$), 14.35(CH$_3$).

1-Hexadecyl-1H-benzo[d]imidazole (b4): Yellow (85% yield), with the following FT-IR cm^{-1} values: 3080 (C-Haromatic), 2928 (C-Haliph), 2845 (C-Haliph), 1621 (C =N), and 1257 (C-N). ^{1}H NMR: 0.88(t, *J* = 6.5 Hz, 3H), 1.26–1.21 (m, 26H, 13x CH$_2$), 1.83–1.77 (p, *J* = 7.0 Hz, 2H), 3.45 (s, 2H), 2.56 (s, 1H), 4.27 (t, *J* = 7.1 Hz, 2H, N–CH$_2$), 7.65–7.18 (m, 4H, Ar–H), 8.20 (s, 1H, NCHN), ^{13}C NMR, δ 144.44(NCHN), 144.17, 135.07, 123.12, 121.74, 119.98, 111.85(Ar-C), 45.24(N-CH$_2$), 31.79, 31.79, 29.84, 29.70, 29.53, 29.51, 29.40, 29.33, 29.21, 29.14, 28.99, 26.58, 26.57, 22.59(14-CH$_2$), 14.41(CH$_3$).

1-Octadecyl-1H-benzo[d]imidazole (b5): Yield percentage (85% yield), with the following FT-IR cm^{-1} values: 3075 (C-Haromatic), 2945 (C-Haliph), 2870 (C-Haliph), 1620 (C =N), and 1258 (C-N). ^{1}H NMR: 0.854(t, *J* = 6.5 Hz, 3H), 1.27–1.21 (m, 26H, 13x CH$_2$), 1.85–1.77 (p, *J* = 7.0 Hz, 2H), 3.46 (s, 2H), 2.57 (s, 1H), 4.25 (t, J = 7.1 Hz, 2H, N–CH2), 7.59–7.22 (m, 4H, Ar–H), 8.21 (s, 1H, NCHN),^{13}C NMR, δ 146.04(NCHN), 142.78, 135.04, 123.11, 121.21, 119.08, 112.14(Ar-C), 45.15(N-CH$_2$), 31.79, 31.79, 29.84, 29.70, 29.53, 29.51, 29.40, 29.33, 29.21, 29.14, 28.99, 26.58, 26.57, 22.59(14-CH$_2$), 14.41(CH$_3$).

Synthesis of (prop-2-yn-1-yloxy) derivatives (t1-t5)

According to the described methods, N-substituted benzimidazole (b1-b5) (20 mmol) was added rabidly to 10 mL of dioxane in a 50 mL. After bringing the reaction's temperature down to below 15 ^{o}C, 2.5 equivalents of the 3-bromo-1-propyne solution were gradually added, in small batches, and the reaction was then left to reflux. For one day, the mixture of reaction was stirred and refluxed at 90 ^{o}C. The organic solvent was evaporated when the chemical reaction was finished, and then methanol was used to recrystallize it.

1-Decyl-3-(prop-2-yn-1-yl)benzimidazolium salts (t1): Yield percentage (79% yield), with the following FT-IR cm^{-1} values: 3268(-C≡CH), 3085(C-H$_{aromatic}$), 2950(C-H$_{aliph}$), 2861(C-H$_{aliph}$), 2130 (-C≡C-), 15621 (C=N),1261(C-N).^{1}H NMR, δ 0.85 (t, *J* = 6.7 Hz, 3H, CH$_3$), 1.16-1.23 (m, 14H, 7 x CH$_2$), 3.64 (s, 1H, C≡C-H), 1.76 (p, *J* = 6.9 Hz, 2H), 4.25 (t, *J* = 7.0 Hz, 2H, N-CH$_2$), 4.86(s, 2H, N-CH$_2$-C≡C), 7.57 - 7.22 (m,4H, Ar-H), 9.25 (s, 1H, NCHN), ^{13}C NMR, δ 145.36(NCHN), 142.91, 134.32, 122.27, 122.07, 121.54, 119.81, 115.78, 110.57(Ar-C), 81.50 (-C≡CH),73.11(-C≡CH),47.14 N-CH$_2$-C≡C), 44.58(N-CH$_2$), 32.78, 29.98, 29.78, 29.28, 29.14, 29.01, 26.69, 22.68(8-CH$_2$), 14.23(CH$_3$).

1-Dodecyl-3-(prop-2-yn-1-yl) benzimidazolium salts (t2): Yield percentage (80% yield), with the following FT-IR cm^{-}

[1] values: 3257 (-C≡CH), (C-$H_{aromatic}$),2941(C-H_{aliph}), 2860(C-H_{aliph}), 2125(-C≡C-), 1628 (C =N),1269 (C-N). ^{1}H NMR, δ 0.81 (t, *J* = 6.6 Hz, 3H), 1.20-1.28 (m, 16H, 9 x CH_2), 1.73 (p, *J* = 6.8 Hz, 2H), 3.63 (s, 1H, C≡C-H), 4.16 (t, *J* = 7.0 Hz, 2H, N-CH_2), 4.82 (s, 2H, N-CH_2-C≡C), 7.62-7.22 (m, 4H, Ar-H), 9.32 (s, 1H, NCHN), ^{13}C NMR, δ 145.31(NCHN), 143.98, 134.21, 122.57, 121.74, 118.21, 111.28(Ar-C),81.58 (-C≡CH),73.35(-C≡CH),47.28 N-CH_2-C≡C), 44.87(N-CH_2), 32.74, 30.09, 29.88, 29.61, 29.38, 26.14, 22.50(10-CH_2), 14.17 (CH_3).

1-Tetradecyl-3-(prop-2-yn-1-yl)benzimidazolium salts (t3): Yield percentage (77% yield), with the following FT-IR cm^{-1} values: 3254(-C≡CH),3071(C-$H_{aromatic}$),2970(C-H_{aliph}), 2858(C-H_{aliph}), 2125(-C≡C-), 1624(C=N),1260 (C-N).^{1}H NMR, δ 0.82 (t, *J* = 6.4 Hz, 3H), 1.21-0.99 (m, 22H, 11x CH_2), 1.77 (p, *J* = 7.0 Hz, 2H), 3.67 (s, 1H, C≡C-H), 4.28 (t, *J* = 7.0 Hz, 2H, N-CH_2), 4.77 (s, 2H, N-CH_2-C≡C), 7.57-7.17 (m, 4H, Ar-H), 9.28 (s, 1H, NCHN), ^{13}C NMR, δ 146.31(NCHN), 142.87, 134.87, 122.84, 121.70, 119.04, 110.11(Ar-C), 81.96 (-C≡CH), 73.12(-C≡CH),47.87 N-CH_2-C≡C),44.62(N-CH_2), 31.97, 29.81, 29.59, 29.50, 29.45, 29.38, 29.30, 29.20, 29.02, 26.87, 22.47(12-CH_2), 14.87(CH_3).

1-Hexadecyl-3-(prop-2-yn-1-yl)benzimidazolium salts (t4): Yield percentage (81% yield), with the following FT-IR cm^{-1} values: 3260(-C≡CH),3078(C-$H_{aromatic}$),2965(C-H_{aliph}), 2848(C-H_{aliph}), 2128(-C≡C-), 1618 (C =N),1252 (C-N).^{1}H NMR, δ 0.86(t, *J* = 6.5 Hz, 3H), 1.28-1.21 (m, 26H, 13x CH_2), 1.83-1.79 (p, *J* = 7.0 Hz, 2H), 3.41 (s, 2H), 2.58 (s, 1H), 3.66 (s, 1H, C≡C-H), 4.25 (t, *J* = 7.0 Hz, 2H, N-CH_2), 4.88 (s, 2H, N-CH_2-C≡C), 7.65–7.21 (m, 4H, Ar-H), 9.20 (s, 1H, NCHN), ^{13}C NMR, δ 144.87(NCHN), 143.47, 134.74, 122.88, 121.70, 119.47, 111.71(Ar-C), 81.74 (-C≡CH),73.65(-C≡CH),47.11 N-CH_2-C≡C), 44.98(N-CH_2), 31.96, 31.81, 29.87, 29.71, 29.58, 29.52, 29.41, 29.35, 29.23, 29.10, 28.78, 26.14, 26.17, 22.50(14-CH_2), 14.78(CH_3).

1-Octadecyl-3-(prop-2-yn-1-yl)benzimidazolium salts (t5): Yield percentage (80% yield), with the following FT-IR cm^{-1} values: 3278(-C≡CH),3085(C-$H_{aromatic}$),2982(C-H_{aliph}), 2858(C-H_{aliph}), 2124(-C≡C-), 1618 (C =N),1256 (C-N).^{1}H NMR, δ 0.85(t, *J* = 6.5 Hz, 3H), 1.26-1.21 (m, 26H, 13x CH_2), 1.86-1.77 (p, *J* = 7.0 Hz, 2H), 2.51 (s, 1H), 3.44 (s, 2H), 3.64 (s, 1H, C≡C-H), 4.24 (t, *J* = 7.0 Hz, 2H, N-CH_2), 4.78 (s, 2H, N-CH_2-C≡C), 7.61–7.19 (m, 4H, Ar-H), 9.14 (s, 1H, NCHN), ^{13}C NMR, δ 144.87(NCHN), 143.82, 134.78, 122.87, 121.71, 119.35, 110.70 (Ar-C),81.75 (-C≡CH),73.47(-C≡CH),47.35 N-CH_2-C≡C),44.51(N-CH_2), 31.98, 31.71, 29.89, 29.71, 29.59, 29.78, 29.41, 29.30, 29.21, 29.04, 28.98, 26.50, 26.41, 22.78(14-CH_2), 14.78 (CH_3).

Synthesis of 1,2,3-triazoles derivatives (tb1-tb5) [50]

(1.2eq) propargyl derivatives (t1-t5) to (0.5mmol) sodium azide dissolved in 17 mL DMF, after 10 minutes of stirring, added (5mol percent) CuSO4.5H2O and (10mol percent) sodium ascorbate. The end point of the chemical reaction was then confirmed by using TLC plate, methanol: dichloromethane (1:9), and the end product solution was left to stir at laboratory temperature.

3-((1H-1,2,3-triazol-4-yl)methyl)-1-decyl-benzimidazolium salts (tb1): Yield percentage (82% yield), with the following FT-IR cm^{-1} values: 3102(C-$H_{aromatic}$), 2987(C-H_{aliph}), 2864(C-H_{aliph}), 1616 (C=N),1265(C-N).^{1}H NMR, δ 0.85 (t, *J* = 6.7 Hz, 3H, CH_3), 1.19-1.29 (m, 14H, 7 x CH_2), 1.74 (p, *J* = 6.9 Hz, 2H), 4.28 (t, *J* = 7.0 Hz, 2H, N-CH_2), 5.24 (s, 2H, N-$CH_{2\text{-triazole ring}}$), 7.62 -7.24 (m,4H, Ar-H), 7.84 (s, 1H, H-triazole ring), 9.25 (s, 1H, NCHN), ^{13}C NMR, δ 144.65(NCHN),144.47, 122.35(2C, carbons of triazole ring), 143.54, 134.74, 122.65, 122.01, 120.77, 119.14, 115.70, 111.70(Ar-C),44.51(N-CH_2), 42.17 N-CH_2-triazole ring), 32.08, 29.98, 29.65, 29.49, 29.21, 29.14, 26.67, 22.68(8-CH_2), 14.28(CH_3).

3-((1H-1,2,3-triazol-4-yl)methyl)-1-dodecyl-benzimidazolium salts (tb2): Yield percentage (84% yield), with the following FT-IR cm^{-1} values: 3098(C-$H_{aromatic}$),2944(C-H_{aliph}), 2864(C-H_{aliph}), 1628 (C =N),1270 (C-N). ^{1}H NMR, δ0.87 (t, *J* = 6.6 Hz, 3H), 1.19-1.24 (m, 16H, 9 x CH_2), 1.78 (p, *J* = 6.8 Hz, 2H), 4.24 (t, *J* = 7.0 Hz, 2H, N-CH_2), 5.18 (s, 2H, N-$CH_{2\text{-triazole ring}}$), 7.73-7.26 (m, 4H, Ar-H), 7.81 (s, 1H, H-triazole ring), 9.30 (s, 1H, NCHN), ^{13}C NMR, δ 144.87(NCHN), 142.58, 122.41(2C, carbons of triazole ring), 144.05, 134.54, 122.02, 121.61, 119.12, 110.45(Ar-C),44.87(N-CH_2), 42.27 N-CH_2-triazole ring), 31.78, 29.88, 29.70, 29.24, 29.15, 26.68, 22.54(10-CH_2), 14.78 (CH_3).

3-((1H-1,2,3-triazol-4-yl)methyl)-1-tetradecyl-benzimidazolium salts (tb3): Yield percentage (80% yield), with the following FT-IR cm^{-1} values: 3097(C-$H_{aromatic}$), 2940(C-H_{aliph}), 2850(C-H_{aliph}), 1612 (C=N),1258 (C-N).^{1}H NMR, δ0.85 (t, *J* = 6.4 Hz, 3H), 1.21-0.96 (m, 22H, 11x CH_2), 1.79 (p, *J* = 7.0 Hz, 2H), 4.27 (t, *J* = 7.1 Hz, 2H, N-CH_2), 5.18 (s, 2H, N-$CH_{2\text{-triazole ring}}$), 7.61-7.18 (m, 4H, Ar-H), 7.81(s, 1H, H-triazole ring), 9.22 (s, 1H, NCHN), ^{13}C NMR, δ 144.89(NCHN), 142.25, 126.70(2C, carbons of triazole ring), 143.87, 134.74, 122.98, 121.47, 119.80, 110.74(Ar-C), 44.57(N-CH_2), 42.17(N-CH_2-triazole ring), 31.89, 29.87, 29.54, 29.47, 29.44, 29.40, 29.32, 29.21, 29.01, 26.54, 22.54(12-CH_2), 14.31(CH_3).

3-((1H-1,2,3-triazol-4-yl)methyl)-1-hexadecyl-benzimidazolium salts (tb4); Yield percentage (77% yield), with the following FT-IR cm^{-1} values: 3085(C-$H_{aromatic}$),2920(C-H_{aliph}), 2851(C-H_{aliph}), 1617 (C =N),1262 (C-N).^{1}H NMR, δ 0.87(t, *J* = 6.5 Hz, 3H), 1.26-1.21 (m, 26H, 13x CH_2), 1.80-1.76 (p, *J* = 7.0 Hz, 2H), 3.44 (s, 2H), 2.52 (s, 1H), 4.26 (t, *J* = 7.1 Hz, 2H, N-CH_2), 5.15 (s, 2H, N-$CH_{2\text{-triazole ring}}$), 7.70–7.19 (m, 4H, Ar-H), 7.80 (s, 1H, H-triazole ring), 9.24 (s, 1H, NCHN), ^{13}C NMR, δ 144.89(NCHN), 142.78, 123.71(2C, carbons of triazole ring), 143.65, 134.20, 122.47, 121.87, 119.98, 110.78(Ar-C), 44.53(N-CH_2), 42.14(N-CH_2-triazole ring), 32.09, 31.89, 29.81, 29.69, 29.51, 29.47, 29.40, 29.31, 29.23, 29.11, 28.91, 26.52, 26.50, 22.52(14-CH_2), 14.48(CH_3).

3-((1H-1,2,3-triazol-4-yl)methyl)-1-octadecyl-benzimidazolium salts (tb5): Yield percentage (82% yield), with the following FT-IR cm^{-1} values: 3105(C-$H_{aromatic}$),2954(C-H_{aliph}), 2874(C-H_{aliph}), 1627 (C =N),1265 (C-N).^{1}H NMR, δ0.88(t, *J* = 6.5 Hz, 3H), 1.27-1.21 (m, 26H, 13x CH_2), 1.81-1.74 (p, *J* = 7.0 Hz, 2H), 3.44 (s, 2H), 2.61 (s, 1H), 4.27 (t, *J* = 7.1 Hz, 2H, N-CH_2), 7.71–7.21 (m, 4H, Ar-H), 7.78 (s, 1H, Htriazole ring), 9.22 (s, 1H, NCHN), ^{13}C NMR, δ 145.14(NCHN), 143.40, 123.74(2C, carbons of triazole ring), 143.84, 134.47, 122.89, 121.54, 120.81, 111.73(Ar-C), 44.87(N-CH_2), 42.74(N-CH_2-triazole ring), 32.54, 31.97, 29.81, 29.71, 29.55, 29.50, 29.44, 29.32, 29.23, 29.13, 28.78, 26.74, 26.51, 22.78(14-CH_2), 14.61(CH_3).

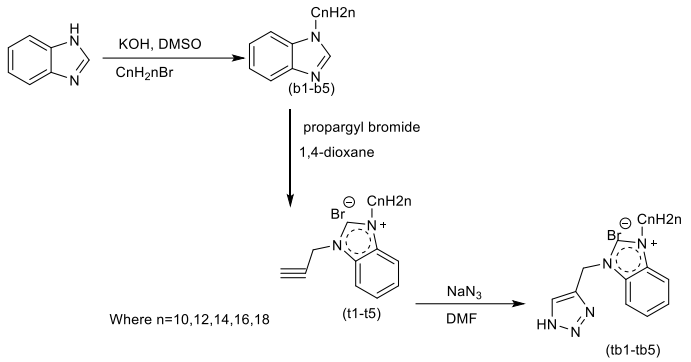
Antibacterial activity

The measurements of newly synthesized compounds (tb1-tb5) was carried out using the pour method, which was modified slightly [51]. Gram-positive *(Staphylococcus aureus)* and negative strains (*Escherichia coli*) were tested. The mean zone area unoccupied by the examined compounds is used to describe the antibacterial capability of newly synthesized complexes [52]. For bacterial growth, nutrient agar culture was utilized. All of the test mixture of end molecules were designed with organic solvent DMSO at a fixed amount of ten milligrams per milliliter. The positive control was ciprofloxacin, whereas the negative control was DMSO. 80 liters of each test sample were placed into wells and incubated at fixed temperature 37 °C for one day. The zoon inhibition was then determined in mm using a Vernier caliper.

Result and Discussion

Synthesis

Bis-benzimidazolium salts containing triazole ring (tb1-tb5) were synthesized in two phases using procedures described in the literature [53–55]. *N*-alkylated benzimidazole derivatives was initially made by reacting starting material benzimidazole with alkyl bromide in the presence strong base (potassium hydroxide) in the first step. The organic solvent used in this process was DMSO. It was possible to obtain the white-colored greasy substance. The removal of acidic hydrogen from nitrogen is followed by a nucleophile center attack on the alkyl halide, which results in the elimination of bromide ions. The second stage involved dissolving 2 equivalents of prepared *N*-alkylated imidazole ring in benzimidazole in 1,4-dioxane solvent and refluxing it with 1 equivalent of propargyl bromide. The free pair electron of nitrogen in benzimidazole linkage the electrophilic position of alkyl bromide and joined with it at a high temperature of roughly 90 °C, creating benzimidazolium salts (t1-t5). The melting points of produced salts were determined, as well as their comprehensive spectrum characterization.



Scheme 1: 1,2,3-Triazole Derivative Synthesis

FT-IR Spectral

Analysis by modifying the distinctive peaks of salts and complexes, spectral characteristics of prepared new benzimidazolium bromide salts and 1,2,3-triazole derivatives can explain the effective synthesis of substances. For confirmation of the effective synthesis, FTIR spectrum of produced salts and1,2,3-triazole derivatives was monitored and modified. The distinctive peak pattern of prepared *N*-alkylated salt is intense between 1500 and 800 cm^{-1}, although it is decreased in bis-benzimidazolium salts. Due to bending vibrations of =C-H group, an intense form of bands in the fingerprint region of infrared spectra, (766 to 647 cm^{-1}), was found in the infrared charts of the prepared benzimidazolium derivatives (t1-t5) and 1,2,3-triazole derivatives for ligands. The occurrence of prominent bands in the all charts of prepared bis-benzimidazolium bromide salts at 2955-2800 cm^{-1}. The four-finger pattern [56] for produced 1,2,3-triazole derivatives and identified bands of H-triazole ring stretching vibration of *N*-alkylated imidazole ring in benzimidazolium bromide salts in the selected region 2100-2050cm^{-1} that appear in synthesized 1,2,3-triazole derivatives give a good indicator for silver complexes preparation [57].

NMR Spectroscopy

In DMSO as a solvent, ^{1}H NMR and ^{13}C NMR charts of prepared benzimidazolium bromide salts and their 1,2,3-triazole derivatives were recorded. In the 9.22-9.25 ppm range, salts (t1-t5) contain obvious peaks of an acidic proton that attached carbon carbene (NCHN). This acidic proton in the salts (t1-t5) is replaced by silver ion in the prepared 1,2,3-triazole derivatives (tb1-tb5) [58]. This is a very good indicator of a successful silver complexes synthesis. ^{13}C NMR spectra of prepared salts (t1-t5) exhibited the importance peaks due to carbon that attached acidic proton in the range of 144.87-146.07 ppm whereas the value of carbon of triazole ring 1,2,3-triazole derivatives appearance at 145-143 ppm. This information exhibits the effective synthesis of end products that contain 1,2,3-triazole compounds and their salts.

MIC Value

Two different types of microorganisms were tested with each of the 1,2,3-triazole derivatives (tb1–tb5) are [gram-negative *Escherichia coli*] and [gram-positive *Staphylococcus aureus*] bacteria. All complexes solutions were prepared in organic solvent (DMSO) that produced at a fixed concentration of 10 mg/mL. All microorganisms have been creating to be inert against DMSO [59–61]. Ciprofloxacin was administered at the same concentration as a typical medication against bacterial strains. All of the compounds were confirmed to be efficacious against evaluated strains, and the values of region inhibition were given in millimeters. Several studies have already been conducted on the biological applications of 1,2,3-triazole derivatives [61]. Ciprofloxacin, a common antibiotic, showed 10.2 mm for S. Aureus and 10.4 mm for *E. Coli* strain. On the other hand, the 1,2,3-triazole derivatives exhibited good zone inhibition of 6.8, 5.4, 5.2, 4.5, 5.3 mm for S. Aureus and 5.4, 3.8, 4.2, 3.3, 4.9 mm for *E. Coli* strain, indicating that the silver core contributed significantly to bacterial growth suppression. The objective of this investigation was to ascertain whether 1,2,3-triazole derivatives exhibit significant MIC antibacterial persistence. Figure 1 shows the effect of antibacterial activity.

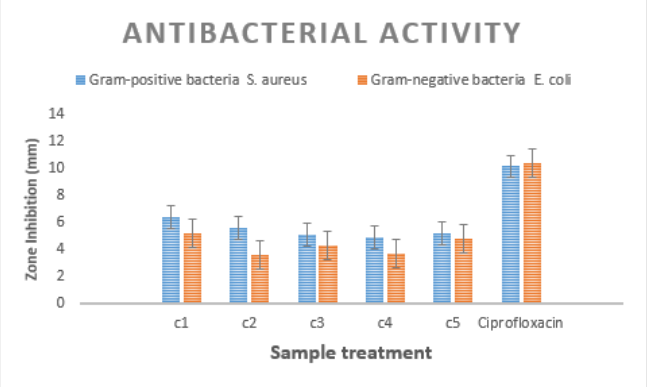


Figure 1: Complexes (tb1-tb5) created synthetically have antibacterial activity

Conclusion

Preliminary procedures were used to produce and characterize 1,2,3-triazole derivatives (tb1-tb5). FTIR and NMR spectroscopy investigations revealed that the chemicals were successfully synthesized. The antibacterial activity of all produced 1,2,3-triazole derivatives (tb1-tb5) was evaluated against gram-positive *S. Aureus* and gram-negative *E. Coli* bacterial strains, and the complexes were found to be bacteriostatically stable. With increasing concentration, the 1,2,3-triazole derivatives showed a good scavenging trend.

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