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Synthesis and biological activity of new silver complexes with N-heterocyclic carbene ligands

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***Abstract*---**Silver complexes of N-heterocyclic carbene (NHC) have been synthesized, structured, and tested for antibacterial activity. All of the silver–NHC complexes (10–13) were made by reacting benzimidazolium salts with Ag_2O at room temperature in dichloromethane as a solvent. The hypothesized structures are supported by ^1H NMR, 13 C NMR, and IR analysis of the novel compounds. In vitro antibacterial efficacy against Gram-positive S. aureus and Gram-negative Bacteria E. coli was tested on a number of novel Ag–NHC complexes.

***Keywords*---**N-heterocyclic carbine, complexes, silver–NHC complexes, antibacterial activity.

Introduction

Over the last few decades, N-heterocyclic carbenes (NHCs) have emerged as a flexible class of dative ligands in metal coordination chemistry, particularly in the field of homogeneous catalysis [1,2]. The metal–NHC complexes have outstanding catalytic activity for a wide range of practical organic transformations, including the C–C [5–7] and C–N cross coupling reactions [8], C–H bond activation [9], and metathesis [10–13]. Among the NHC–metal complexes, Ag–NHC complexes have been exploited for a range of applications. Carbine transfer reagents for the generation of new NHC–metal complexes [14-17], (ii) catalysis [18–20], (iii) antimicrobial activity [21–25], and (iv) nanomaterials are among these. NHC–silver complexes are formed by reacting an imidazolium (or benzimidazolium) salt with

silver compounds in a single pot. The silver–carbene can be made from a number of silver compounds, including Ag_2O [26], AgOAc [27], and Ag_2CO_3 [28]. Among them, silver oxide is the most commonly used. The Ag2O method for synthesizing Ag–NHC offers a number of advantages, including being generally stable and accessible, the capacity to carry out reactions at room temperature, the lack of solvent pretreatments and strong bases, and the ability to maintain chirality [17]. In NHC chemistry, carbene ligands based on imidazole, imidazoline, and benzimidazole are the most common. Benzimidazolylidene-containing transition metal complexes have recently been discovered to have various properties that are significantly different from those of the corresponding imidazolylidene complexes as both homogeneous catalysts and materials [29–31]. This paper describes the synthesis and characterization of Ag(I) complexes with benzimidazolylidene ligands. A number of new Ag–NHC complexes were investigated in vitro for antibacterial activity against a variety of Gram-positive and Gram-negative bacteria.

Experimental

General procedures

All solvents and chemicals were acquired commercially and were of the highest analytical grade from Sigma–Aldrich and Fluka. Infrared spectra were recorded using the Fourier transformation infrared Bruker ALPHA FT-IR, Faculty of Science, University of Kufa. 1H and 13C NMR spectra in DMSO-d6 were acquired on the Bruker spectrometer (300MHz for 1H NMR and 75MHz for 13C NMR, respectively) at Shahid Beheshti University/Iran d6 with tetramethylsilane as an internal reference. The abbreviations for NMR multiplicities are as follows: s = singlet, d = doublet, t = triplet, and m = multiplet signal. Melting points are measured using the Electro Thermal Melting Point Apparatus from the United Kingdom. The visualization was created using a UV Cabinet with Aluminum TLC Xtra SIL G/UV245 with silica 60, thickness 0.2, and a 10x20cm surface area in Germany (254 nm).

Synthesis 2-chloro-N-(4-(4-(2-chloroacetyl)benzyl)phenyl)acetamide

15 mmol of 4,4'-methylenedianiline was dissolved in DCM (20 mL) and then trimethylamine was added to make 2-chloro-N-(4-(4-(2-chloroacetyl)benzyl) phenyl)acetamide (1). (1.5 mL). The mixture was agitated for 20 minutes before adding the chloroacetyl chloride (1:2) (30 mmol) dropwise at below 10°C and stirring for another 30 minutes. Filter and wash thoroughly with distilled water after completing the reaction, and then recrystallize with ethanol.

N,N'-([1,1'-biphenyl]-4,4'-diyl)bis(2-chloroacetamide) (1): It was prepared as a fine white powder (89 % yield), (m.p.:267-269 ℃), FT-IR cm^{-1}: 3260(N-H),3092(C-$H_{aromatic}$), 2950(C-H_{aliph}), 2853(C-H_{aliph}), 1660(N-carbonyl), 1548(C=N), 1243 (C-N). ^{1}H NMR (300 MHz, DMSO-d_6) δ 10.09 (s, 1H, Ar-NH), 7.53-7.21 (m, 8H, Ar-H), 4.41 (s, 2H, -NH-CH_2).

Synthesis *N*-Substituted Benzimidazole

After grinding, 15 mmol benzimidazole was mixed in 20 mL DMSO, and 20 mmol NaOH was added. At 90°C, the mixture was agitated for 2 hours. After cooling to 30°C, dropwise additions of 1-bromoalkane (20 mmol) were made, and the temperature was raised to 40°C for 1 hour. Petroleum ether was used to extract the product, which was put into 10 mL distilled water (3X10 mL). The petroleum ether was removed after it was filtered.

1-decyl-1H-benzo[d]imidazole (2): It was prepared as a Clear yellow (81 % yield), FT-IR cm^{-1}: 3050(C-$H_{aromatic}$), 2920(C-H_{aliph}), 2853(C-H_{aliph}), 1558 (C=N),1252(C-N).^{1}H NMR (301 MHz, DMSO-d_6) δ 8.25 (s, 1H, NCHN), 7.68 -7.22 (m,4H, Ar-H), 4.21 (t, *J* = 7.0 Hz, 2H, N-CH_2), 1.76 (p, *J* = 6.9 Hz, 2H), 1.18-1.25 (m, 14H, 7 x CH_2), 0.83 (t, *J* = 6.7 Hz, 3H, CH_3), ^{13}C NMR (76 MHz, DMSO-d_6) 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 (3): It was prepared as a Clear yellow (79 %), FT-IR cm^{-1}: 3052(C-$H_{aromatic}$),2919(C-H_{aliph}),, 2852(C-H_{aliph}), 1686 (C =N),1277 (C-N). ^{1}H NMR (301 MHz, DMSO-d_6) δ 8.23 (s, 1H, NCHN), 7.73-7.21 (m, 4H, Ar-H), 4.20 (t, *J* = 7.0 Hz, 2H, N-CH_2), 1.76 (p, *J* = 6.8 Hz, 2H), 1.18-1.26 (m, 16H, 9 x CH_2), 0.83 (t, *J* = 6.6 Hz, 3H), ^{13}C NMR (76 MHz, DMSO-d_6) 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 (4): It was prepared as a Clear yellow (86 % yield), FT-IR cm^{-1}: 3053(C-$H_{aromatic}$), 2920(C-H_{aliph}), 2853(C-H_{aliph}), 1617 (C=N),1252 (C-N).^{1}H NMR (301 MHz, DMSO-d_6) δ 8.22 (s, 1H, NCHN), 7.66-7.13 (m, 4H, Ar-H), 4.21 (t, *J* = 7.1 Hz, 2H, N-CH_2), 1.76 (p, *J* = 7.0 Hz, 2H), 1.20-0.96 (m, 22H, 11x CH_2), 0.83 (t, *J* = 6.4 Hz, 3H), ^{13}C NMR (76 MHz, DMSO-d6) δ 144.36(NCHN), 143.91, 134.21, 122.55, 121.74, 119.86, 110.68(Ar-C), 44.52(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 (5): It was prepared as a Clear yellow (85 % yield), FT-IR cm^{-1}: 3053(C-$H_{aromatic}$),2921(C-H_{aliph}), 2854(C-H_{aliph}), 1616 (C =N),1250 (C-N).^{1}H NMR (301 MHz, DMSO-d_6) δ 8.24 (s, 1H, NCHN), 7.71–7.15 (m, 4H, Ar-H), 4.25 (t, *J* = 7.1 Hz, 2H, N-CH_2), 3.40 (s, 2H), 2.56 (s, 1H), 1.84-1.78 (p, *J* = 7.0 Hz, 2H), 1.25-1.20 (m, 26H, 13x CH_2), 0.87(t, *J* = 6.5 Hz, 3H), ^{13}C NMR (76 MHz, DMSO-d6) δ 144.44(NCHN), 143.93, 134.24, 122.58, 121.76, 119.88, 110.78(Ar-C), 44.51(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 1,3-disubstituted benzimidazolium salts (6,7,8 and 9)

All of the 1,3-disubstituted benzimidazolium salts (6,7,8, and 9) were made using the procedures described. [22] A 50 mL round bottom flask was filled with 20 mmol N-substituted benzimidazole (2,3,4 and 5) in 10 mL dioxane. N,N'-([1,1'-biphenyl]-4,4'-diyl)bis(2-chloroacetamide) was added to the mixture at a concentration of 10 mmol. For 24 hours, the mixture was refluxed at 90 degrees

Celsius. The solvent was evaporated once the reaction was completed and then recrystallized with methanol.

6: It was prepared as a powder (74 % yield) (m.p=130-132 ℃). FT-IR cm^{-1}: 3287(N-H),3087(C-$H_{aromatic}$), 2918(C-H_{aliph}), 2851(C-H_{aliph}), 1668(N-carbonyl), 1234 (C-N). ^{1}H NMR (300 MHz, DMSO-d6) δ, ppm: 10.12 (s, 1H, Ar-NH), 9.84 (s, 1H, NCHN), 7.57-7.24 (m, 8H, Ar-H), 4.96 (t, J = 6.3 Hz, 2H, N-CH2), 4.37 (s, 2H, -NH-CH_2), 3.87 (s, 2H, ph-CH_2-ph), 1.76 (p, J = 6.5 Hz, 2H, CH2), 1.25 – 1.33 (m, 22H,CH2), 0.91 (m, 3H,CH3), ^{13}C NMR (75 MHz, DMSO-d6) δ 167.87, 137.57 (NCHN), 139.43, 136.25, 135.67, 132.99, 127.61, 126.44, 126.35, 119.94, 108.77, 108.46 (aromatic carbons), 52.85, 51.19, 31.82, 29.64, 29.44, 29.42, 29.26, 27.50, 26.02, 22.76, 14.11.

7: It was prepared as a powder (71 % yield) (m.p=144-146 ℃), FT-IR cm^{-1}: 3261(N-H),3099(C-$H_{aromatic}$), 2919(C-H_{aliph}), 2852 (C-H_{aliph}), 1664(N-carbonyl), 1248 (C-N). ^{1}H NMR (300 MHz, DMSO-d6) δ, ppm: 10.10 (s, 1H, Ar-NH), 9.81 (s, 1H, NCHN), 7.55-7.23 (m, 8H, Ar-H), 4.93 (t, J = 6.2 Hz, 2H, N-CH2), 4.35 (s, 2H, -NH-CH_2), 3.82 (s, 2H, ph-CH_2-ph), 1.73 (p, J = 6.4 Hz, 2H, CH2), 1.23 – 1.36 (m, 22H,CH2), 0.93 (m, 3H,CH3), ^{13}C NMR (75 MHz, DMSO-d6) δ 169.03, 137.25(NCHN), 139.44, 136.21, 135.70, 132.95, 127.64, 126.41, 126.38, 119.93, 108.80, 108.41 (aromatic carbons), 52.80, 51.28, 31.84, 29.46, 29.44, 29.41, 29.26, 29.10, 27.52, 26.01, 22.75, 14.09.

8: It was prepared as a powder (81 % yield) (m.p=171-173 ℃), FT-IR cm^{-1}: 3288(N-H), 3087(C-$H_{aromatic}$), 2920(C-H_{aliph}), 2853 (C-H_{aliph}), 1660(N-carbonyl), 1232 (C-N). ^{1}H NMR (300 MHz, DMSO-d6) δ, ppm: 10.18 (s, 1H, Ar-NH), 9.86 (s, 1H, NCHN), 7.55-7.29 (m, 8H, Ar-H), 4.94 (t, J = 6.3 Hz, 2H, N-CH2), 4.32 (s, 2H, -NH-CH_2), 3.88 (s, 2H, ph-CH_2-ph), 1.77 (p, J = 6.5 Hz, 2H, CH2), 1.20 – 1.29 (m, 22H,CH2), 0.97 (m, 3H,CH3), ^{13}C NMR (75 MHz, DMSO-d6) δ 167.90, 137.01 (NCHN), 139.40, 136.26, 135.69, 133.03, 127.65, 126.50, 126.31, 119.90, 108.72, 108.55 (aromatic carbons), 52.90, 51.20, 31.91, 29.39, 29.38, 29.40, 29.31, 29.27, 29.21, 29.16, 29.13, 27.49, 26.09, 22.80, 14.09.

9: It was prepared as a powder (83 % yield) (m.p=187-189 ℃), FT-IR cm^{-1}: 3243(N-H), 3054(C-$H_{aromatic}$), 2921(C-H_{aliph}), 2854 (C-H_{aliph}), 1617(N-carbonyl), 1252 (C-N). ^{1}H NMR (300 MHz, DMSO-d6) δ, ppm: 10.09 (s, 1H, Ar-NH), 9.80 (s, 1H, NCHN), 7.51-7.27 (m, 8H, Ar-H), 5.01 (t, J = 6.3 Hz, 2H, N-CH2), 4.41 (s, 2H, -NH-CH_2), 3.82 (s, 2H, ph-CH_2-ph), 1.71 (p, J = 6.5 Hz, 2H, CH2), 1.23 – 1.29 (m, 22H, CH2), 0.96 (m, 3H,CH_3), ^{13}C NMR (75 MHz, DMSO-d6) δ 167.98, 137.10 (NCHN), 139.51, 136.30, 135.81, 132.12, 127.70, 126.51, 126.28, 119.88, 108.86, 108.37, (aromatic carbons), 52.85, 51.14, 31.91, 29.49, 29.43, 29.45, 29.35, 29.30, 29.22, 29.26, 29.19, 29.19, 29.11, 29.07, 27.46, 26.07, 22.82, 14.06.

Synthesis of silver(I)–*N*HC complexes (10,11,12 and 13)

Silver oxide (2 mmol) was mixed in 20 mL acetonitrile with 1,3-disubstituted benzimidazolium salts (6,7,8, and 9) solution (1 mmol). In a glassware covered with aluminum foil, stirred the mixture for 8-10 hours. The dark suspension was then filtered through celite to remove any excess Ag2O, and the solvent was evaporated using a rotary evaporator.

10: It was prepared as a solid product (73 % yield) (m.p = 221-223 ℃). FT-IR cm^{-1}: 3252(N-H),3054(C-$H_{aromatic}$), 2921(C-H_{aliph}), 2855(C-H_{aliph}), 1665(N-carbonyl), 1258 (C-N). ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm: 10.05 (s, 2H, Ar-NH), 7.40-7.01 (s, 16H, Ar-H), 4.54 (s, 4H, carbonyl-CH_2-N), 3.71 (t, J = 6.4 Hz, 4H, N-CH_2), 1.99-1.83 (p, J = 6.6 Hz, 4H, CH_2), 1.39–1.21 (m, 36H,CH_2), 0.94 (t, J = 6.2 Hz, 6H,CH_3). ^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm: 185.98(C-Ag),165.78(C=O), 161.95(Ar-C-N), 133.09,127.34,126.61, 123.43,121.93 (Ar-C),125.13, 123.17, 56.76 (carbonyl -CH_2-N), 54.29(N-CH_2-),40.21, 40.09, 39.76,39.56, 39.12,33.76, 31.94, 31.39, 29.76, 29.56,29.34,29.23, 28.78, 27.41,24.96, 23.67,22.97(-CH_2),12.98(-CH_3)

11: It was prepared as a solid product (68 % yield) (m.p = 188-190 ℃). FT-IR cm^{-1}: 3266(N-H),3097(C-Haromatic), 2922(C-Haliph), 2851(C-Haliph), 1673(N-carbonyl), 1249 (C-N). ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm: 10.08 (s, 2H,Ar-NH), 7.41-6.99 (s, 16H, Ar-H), 4.50 (s, 4H, carbonyl-CH_2-N), 3.75(t, J = 6.4 Hz, 4H, N-CH_2), 1.92-1.82 (p, J = 6.6 Hz, 4H,CH_2), 1.40–1.20 (m, 36H,CH_2), 0.95 (t, J = 6.2 Hz, 6H,CH_3).

^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm: 185.84(C-Ag),164.87(C=O), 161.66(Ar-C-N), 132.87,129.04,127.74,123.78, 122.89 (Ar-C),124.51, 123.24, 55.89 (carbonyl-CH_2-N), 54.51(N-CH_2-),41.08, 40.01, 39.86,39.46, 39.22,33.78, 31.82, 31.24, 29.65, 29.47,29.31,29.21, 28.89, 28.38, 27.35,27.13,24.78, 23.64,22.75(-CH_2),12.87(-CH_3)

12: It was prepared as a solid product (74 % yield) (m.p = 204-206 ℃), FT-IR cm^{-1}: 3253(N-H),3117(C-Haromatic), 2921(C-Haliph), 2851(C-Haliph), 1673(N-carbonyl), 1251 (C-N). ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm: 10.09 (s, 2H,Ar-NH), 7.41-7.12 (s, 16H, Ar-H), 4.58 (s, 4H, carbonyl-CH_2-N), 3.73(t, J = 6.4 Hz, 4H, N-CH_2), 1.98-1.82 (p, J = 6.6 Hz, 4H,CH_2), 1.40–1.22 (m, 36H,CH_2), 0.97 (t, J = 6.2 Hz, 6H,CH_3).

^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm: 185.14(C-Ag),164.65(C=O), 161.27(Ar-C-N), 133.44,130.48,127.25,123.47, 122.21 (Ar-C),124.24, 123.08, 55.28 (carbonyl-CH_2-N), 54.74(N-CH_2-),41.78, 40.08, 39.98,39.27, 38.81,33.45, 31.57, 30.84, 29.78, 29.54,29.11,28.88, 28.49, 28.18,27.89,27.46,27.13,24.95, 23.47,22.70 (-CH_2) ,12.17(-CH_3)

13: It was prepared as a solid product (71 % yield) (m.p = 235-237 ℃), FT-IR cm^{-1}: 3254(N-H),3088(C-Haromatic), 2989(C-Haliph), 2851(C-Haliph), 1661(N-carbonyl), 1237 (C-N). ^{1}H NMR (300 MHz, DMSO-d_6) δ, ppm: 10.02 (s, 2H,Ar-NH), 7.39-7.09 (s, 16H, Ar-H), 4.52 (s, 4H, carbonyl-CH_2-N), 3.70(t, J = 6.4 Hz, 4H, N-CH_2), 1.98-1.80 (p, J = 6.6 Hz, 4H,CH_2), 1.36–1.19 (m, 36H,CH_2), 0.94 (t, J = 6.2 Hz, 6H,CH_3).

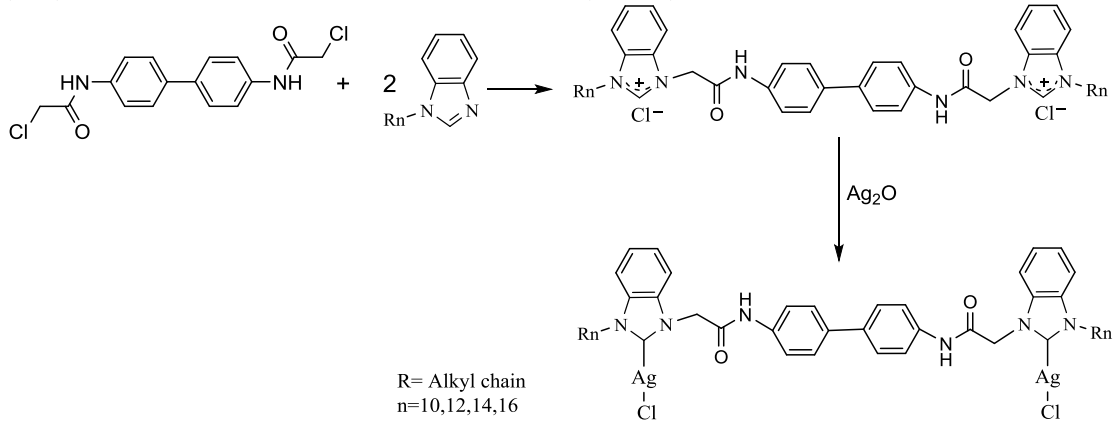
^{13}C NMR (75 MHz, DMSO-d_6) δ, ppm: 186.11(C-Ag),165.15(C=O), 161.07(Ar-C-N), 134.41,131.74,128.58,123.68, 122.45 (Ar-C),124.38, 123.13, 55.57 (carbonyl-CH_2-N), 55.34(N-CH_2-),42.14, 40.18, 39.92,39.37, 38.71,33.84, 31.87, 31.80, 29.97, 29.61, 29.02, 28.78, 28.61, 28.47, 28.27, 27.94, 27.63,27.41,27.11,24.91,23.54, 22.71(-CH_2) ,12.35(-CH_3).

Antibacterial activity test [32]

The antibacterial activity of ligands (7 and 9) and complexes (11 and 13) against Staphylococcus aureus and Escherichia coli was determined by measuring the inhibitory zone in Muller Hinton agar (6mm). Azithromycin (100,200) g/mL was the gold standard for antibacterial activity. Each bacteria isolate was inoculation on Muller-Hinton Agar [sterilize in autoclave] by dipping a cotton swab in the solution and streaking across the surface of the agar plates. The cemented material was then bored with four holes (6 mm). These holes were filled with (0.5 mL) of the generated compounds (100,200 g/mL diluted in 1 mL DMSO solvent). The zone inhibition was measured after 24 hours of incubation at 37 °C.

Results and Discussion

The initial portion of this research focused on chemical (1), which was made by reacting benzidine with chloroacetyl chloride (1:2). In the second step, produced compounds were N-alkylated (2,3,4,5) using NaOH as a basis for removing acidic protons from benzimidazole (N-H) in DMSO as the solvent and the matching bromoalkyle. Then, using the reaction 2-chloro-N-(4-(2-chloroacetyl)benzyl) phenyl)acetamide (1) with N-Substituted Benzimidazole (2-5) in dioxane as solvent, asymmetrically substituted N,N-disubstituted benzimidazolium chloride salts (6-9) were obtained in a solid state in good yield. The Ag-NHC complexes were synthesized in a manner similar to that described by Wang and Lin 15 in the final portion. To make the required Ag-NHC complexes, the benzimidazolium salts (6-9) were treated with silver oxide in dioxin (10-13). depicted in Scheme 1.



Scheme 1: Synthesis of bis-benzeimidazolium salt and its complexes

FTIR data

Compound (1)'s FT-IR spectra revealed the following bands, which were assigned as follows: 3257 cm-1 due to (N-H) stretching vibration, 1662 cm-1 due to (C=O) group. The FTIR spectra of N-alkylation (2-5) revealed a significant band due to symmetric and asymmetric -CH aliphatic in the alkyl chain at (2857 and 2923 cm-1), as well as a band at 1608 cm-1 due to (C=N) in the imidazole ring. The following bands were seen in the FT-IR spectra of ligand (6-9), which were ascribed as follows: a band at 3285 cm-1 due to (N-H) stretching vibration, 1664

cm-1 due to (C=O) group, and a strong band due to symmetric and asymmetric -CH aliphatic in alkyl chain at 1664 cm-1 (2857and 2923 cm-1). The ligand bands in the FT-IR spectra of complexes (10-13) were the same, however the bond between (C-Ag) bands appeared to be smaller than 400 cm-1.

NMR data

The 1H NMR of compound (1) in DMSO-d6 revealed a new singlet signal at (10.05) ppm, which was attributed to the amide proton (NHCO). In the highest upfield area, the spectra of compounds (2-5) exhibited a disappearing peak of the NH group in benzimidazole and a significant peak owing to –CH2 aliphatic in alkyl chain multiples signal at (1.33 – 1.22) ppm, and the –CH3 protons generate a triplet signal around (0.88 – 0.84) ppm. The spectra of ligands (6-9) revealed a significant peak owing to–CH2 aliphatic in alkyl chain multiples signal at (1.35 – 1.18) ppm, which was ascribed to amide proton (NHCO) and a singlet peak at (10.05) ppm, which was assigned to CH carbon carbene. The –CH3 protons, on the other hand, provide a triplet signal of roughly (0.91) ppm. Singlet signal at (10.01) ppm was assigned to amide proton in the spectra of complexes (10-13). (NHCO). Furthermore, the successful coordination of carbon carbene with silver (I) complexes via deprotonation in the C2 of the benzimidazole ring, resulting in the disappearance of the signal at (10.08) ppm in the complexes spectrum. The C2 carbon in ligands (6-9) causes the 13CNMR most characteristic resonance to occur about 137.40 and 135.55 ppm, whereas the signal of (C-Ag) appears at 185.95 in complexes (16,17,18,19). When the resonances of methyl(-CH3) and methylene(-CH2-) carbons are in the 12.95-40.40 ppm range.

The Antibacterial Activity Test

The antibacterial efficacy of substituted benzoimidazolium salts and their N-heterocyclic carbene corresponding Ag(I) complexes against E. coli, a representative gram-negative bacterium, and S. aureus, a gram-positive pathogen, was examined using azithromycin as a benchmark. When compared to azithromycin, all of the substituted benzoimidazolium salts and related Ag(I) complexes demonstrated efficacy against the bacteria studied. A realistic representation of the zone of inhibition is presented in this picture (Table 1). According to the tabulated findings, (10) has the strongest antibacterial activity and showed good inhibition against the studied bacteria, even more than azithromycin. The ligand has a modest activity, while the complex has a moderate activity (13). On the other hand, *E. coli*, demonstrated the highest level of resistance to the complex (10). The sensitivity of gram negative bacteria increases as the number of complex suspensions increases. As demonstrated in, the results for the bacteria S. aureus were nearly equal to those for *E. coli* (Table 1). The ligand (6) had a low bactericidal activity. Similarly, the sensitivity of the gram positive bacteria increases as the volume of the complex suspensions grows. All other chemicals obtained different results at concentrations of 100 and 200 g ml-1[19].

Table 1: Antibacterial activities of compounds 6,8,10 and 12 against *E.coli.* and *S. aureus*

Compound	*E.coli.* Inhibition zone (mm)		*S. aureus* Inhibition zone (mm)	
	100 μg mL^{-1}	200 μg mL^{-1}	100 μg mL^{-1}	200 μg mL^{-1}
6	15	20	12	16
8	25	30	25	30
10	35	40	25	35
12	25	35	20	30
AZ	30	40	20	30

Conclusions

Preparation of new benzimidazolium salts, as well as new Ag(I)-NHC complexes of benzimidazolium salts (6,7,8, and 9) and characterisation utilizing 1H, 13C NMR spectroscopy, FT-IR spectrophotometer, CHN elemental analysis, and melting point These compounds were made utilizing an in situ process that involved reacting Ag2O with an NHC precursor salt in a suitable solvent such as dichloromethane, dioxane (10,11,12,13). The capacity of the NHC salt and its Ag(I) complexes to kill germs is discussed.

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