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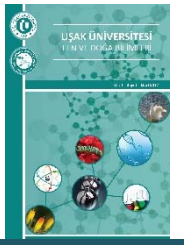

Research Article (Araştırma Makalesi)

Synthesis, Characterization, Anti-Microbial Activity Studies of 2-Methoxy-5-sulfamoylbenzoic Acid and 2-Amino-5/6-picoline Salts and Their Cu(II) Complexes

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Abstract

Two new salts (1 and 2) obtained between 2-methoxy-5-sulfamoylbenzoic acid (Hsba) and 2-amino-X-picoline {X = 5 (2a5mp) and 6 (2a6mp)} and their Cu(II) complexes (3 and 4) have been obtained. The structures of the salts (1 and 2) were suggested by elemental analysis, Nuclear Magnetic Resonance Spectroscopy (NMR), Fourier-Transform Infrared Spectroscopy (FT-IR) and UV-Vis, while the structures of Cu(II) complexes (3 and 4) were suggested by elemental analysis, AAS, UV-Vis and magnetic susceptibility techniques. While the acid:base ratio was 1:1 for 1 and 2 salts, the metal:acid:base ratio was 1:2:2 for 3 and 4. According to the results of spectroscopic analysis, the structures of 3 and 4 compounds were proposed as octahedral. Additionally, anti-microbial activities of free ligands, salts and complexes were studied against *Pseudomonas aeruginosa* (ATCC 27853), *Staphylococcus aureus* (NRRL B-767), *Bacillus subtilis*, *Enterococcus faecalis* (ATCC 29212), *Escherichia coli* (ATCC25922) and *Listeria monocytogenes* (ATCC 7644) bacteria and *Candida albicans* (F89) yeast. The results were comparisoned with the antibiotics (Fluconazole, Vancomycin, Cefepime and Levofloxacin). All compounds showed activity against bacteria and yeasts. Compounds $Cu(OAc)_2.2H_2O$, 2 and 4 for *C. albicans*, Hsba and 3 for *L. monocytogenes*, 2a5mp for *B. subtilis,* all compounds (except Hsba and 2) for *E. coli*, Hsba for *S. aureus*, 1 for *E. faecalis* and Hsba and 3 for *P. aeruginosa* have the best activity. Some of the most prevalent pathogens that cause a wide range of diseases in humans are specific types of bacteria and fungi. As a result, the potential for creating new anti-bacterials using these synthesized compounds (1-4) may be assessed.

Keywords: *2-Aminopicoline, 2-methoxy-5-sulfamoylbenzoic acid, salt, Cu(II) complexes, anti-bacterial activity, anti-fungal activity.*

2-Metoksi-5-sülfamoilbenzoik Asit ve 2-Amino-5/6-pikolin Tuzla-rı ve Bunların Cu(II) Komplekslerinin Sentezi, Karakterizasyonu, Anti-Mikrobiyal Aktivite Çalışmaları

Özet

2-Metoksi-5-sülfamoilbenzoik asit (Hsba) ve 2-amino-X-pikolin {X = 5 (2a5mp) ve 6 (2a6mp)} arasında elde edilen iki yeni tuz (1 ve 2) ve bunların Cu(II) kompleksleri (3 ve 4) elde edilmiştir. Tuzların (1 ve 2) yapıları

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elementel analiz, Nükleer Manyetik Rezonans Spektroskopisi (NMR), Fourier Dönüşümü Kızılötesi Spektroskopisi (FT-IR) ve UV-Vis ile Cu(II) komplekslerinin (3 ve 4) yapıları ise elementel analiz, AAS, UV-Vis ve manyetik duyarlılık teknikleri ile önerilmiştir. 1 ve 2 tuzları için asit:baz oranı 1:1 iken, 3 ve 4 kompleksleri için metal:asit:baz oranı 1:2:2'dir. Spektroskopik analiz sonuçlarına göre 3 ve 4 bileşiklerinin yapıları oktahedral olarak önerilmiştir. Ayrıca, serbest ligandların, tuzların ve komplekslerin anti-mikrobiyal aktiviteleri *Pseudomonas aeruginosa* (ATCC 27853), *Staphylococcus aureus* (NRRL B-767), *Bacillus subtilis*, *Enterococcus faecalis* (ATCC 29212), *Escherichia coli* (ATCC25922) ve *Listeria monocytogenes* (ATCC 7644) bakterilerine ve *Candida albicans* (F89) mayasına karşı çalışılmıştır. Sonuçlar antibiyotiklerle (Fluconazole, Vancomycin, Cefepime ve Levofloxacin) karşılaştırılmıştır. Tüm bileşikler bakteri ve mayalara karşı aktivite göstermiştir. C. albicans için $Cu(OAc)_2.2H_2O$, 2 ve 4 (31.25 µg/mL), *L. monocytogenes* için Hsba ve 3 (31,25 µg/mL), *B. subtilis* için 2a5mp (7,80 µg/mL), *E. coli* için tüm bileşikler (Hsba ve 2 hariç) (62,50 µg/mL), *S. aureus* için Hsba (31,25 µg/mL), *E. faecalis* için 1 (31,25 µg/mL) ve *P. aeruginosa* için Hsba ve 3 (15,60 µg/mL) en iyi aktiviteye sahiptir. İnsanlarda çok çeşitli hastalıklara neden olan en yaygın patojenlerden bazıları, spesifik bakteri ve mantar türleridir. Sonuç olarak, sentezlenen bu bileşikleri (1-4) kullanarak yeni anti-bakteriyeller oluşturma potansiyeli değerlendirilebilir.

Anahtar Kelimeler: *2-Aminopikolin, 2-metoksi-5-sülfamoilbenzoik asit, tuz, Cu(II) kompleksleri, anti-bakteriyel aktivite, anti-fungal aktivite.*

1. Introduction

Proton transfer reactions between an acid and a base appear in many natural phenomena, from the presence of salts to the zwitterionic nature of common amino acids in habitats or interactions between proteins and substrates [1,2]. Proton transfer salts are compounds that contain positive and negative charges by transferring the unshared electron of the base and the proton of the acid. The ionization of active pharmaceutical ingredients in salts plays a crucial role in the formulation of drugs [2,3]. Salts and metal complexes from salts are generally more soluble than their corresponding non-ionized forms, thus providing drugs with improved pharmacokinetics [4].

2-Methoxy-5-sulfamoylbenzoic acid (Hsba) derivatives have biological properties such as infection treatment, enzyme inhibitor, treatment, meniscus, analgesic, anti-microbial, rheumatism, anti-diabetic and anti-inflammatory [5-12]. In the literature, simple metal complexes of 2-methoxy-5-sulfamoylbenzoic acid [13,14], 2-aminopyridine derivatives with salts and their Cu(II) complexes [11-13,15-18] and were synthesized.

2-Aminopicoline derivatives has biological activity such as anti-convulsant, anti-histaminic, anti-bacterial, anti-fungal, anti-parasitic, anti-diabetic, cardiotonic, analgesic, anti-viral, anti-alzheimer's and anti-inflammatory [19]. 2-Aminopicoline derivatives can coordinate with N or NH_2 with Cu(II) [20,21].

Two new salts (1 and 2) obtained between 2-methoxy-5-sulfamoylbenzoic acid (Hsba) and 2-amino-X-picoline {X = 5 (2a5mp) and 6 (2a6mp)} and their Cu(II) complexes (3 and 4) have been obtained. The structures of the salts (1 and 2) were suggested by elemental analysis, NMR, FT-IR and UV-Vis, while the structures of Cu(II) complexes (3 and 4) were suggested by elemental analysis, AAS, UV-Vis and magnetic susceptibility techniques. While the acid:base ratio was 1:1 for 1 and 2 salts, the metal:acid:base ratio was 1:2:2 for 3 and 4. According to the results of spectroscopic analysis, the structures of 3 and 4 compounds were proposed as octahedral. Additionally, anti-microbial activities of free ligands, salts and complexes were studied against *P. aeruginosa* (ATCC 27853), *S. aureus* (NRRL B-767), *B. subtilis*, *E. faecalis* (ATCC 29212), *E. coli* (ATCC25922) and *L. monocytogenes* (ATCC 7644) bacteria and *C. albicans* (F89) yeast. The results were comparisoned with the antibiotics (Fluconazole, Vancomycin, Cefepime and Levofloxacin).

All compounds showed activity against bacteria and yeasts. As a result, the potential for creating new anti-bacterial using these synthesized compounds (1-4) may be assessed.

2. Experimental Section

2.1. Preparation of Salts and Cu(II) Complexes

5 mmol Hsba (2.3123 g) and 5 mmol 2-aminopicoline (2a5mp for 1 and 2a6mp for 2) dissolved in 100 mL of ethanol. The white amorphous solids were procured by stirring for three hours (80% yield for 1 and 90 yield for 2) (Fig. 1a).

5 mmol salt {1 for 3 and 2 for 4) and 5 mmol $Cu(CH_3COO)_2.H_2O$ was dissolved in water:ethanol solution (1:2) (100 mL) with stirring one week. Purple amorphous solids (74% yield for 6 and 70% yield for 7) were obtained from the mixtures (Fig. 1b).

Anal. Calcd. for 1 ($C_{14}H_{17}N_3O_5S$): C, 45.32%; H, 4.35%; N, 10.07%; S, 11.52%. Found: C, 45.30%; H, 4.37%; N, 10.09%; S, 11.50%; for 2 ($C_{14}H_{17}N_3O_5S$): C, 45.32%; H, 4.35%; N, 10.07%; S, 11.52%. Found: C, 45.36%; H, 4.40%; N, 10.17%; S, 11.60%; Anal. Calcd. for 3 ($C_{28}H_{36}CuN_6O_{12}S_2$): C, 43.32 %; H, 4.67%; Cu, 8.19%; N, 10.83%; S, 8.26%. Found: C, 43.30%; H, 4.80%; Cu, 8.30%; N, 10.85 %; S, 8.30%; Anal. Calcd. for 4 ($C_{28}H_{36}CuN_6O_{12}S_2$): C, 43.32 %; H, 4.67%; Cu, 8.19%; N, 10.83%; S, 8.26%. Found: C, 43.30%; H, 4.60%; Cu, 8.10%; N, 10.80%; S, 8.25%.

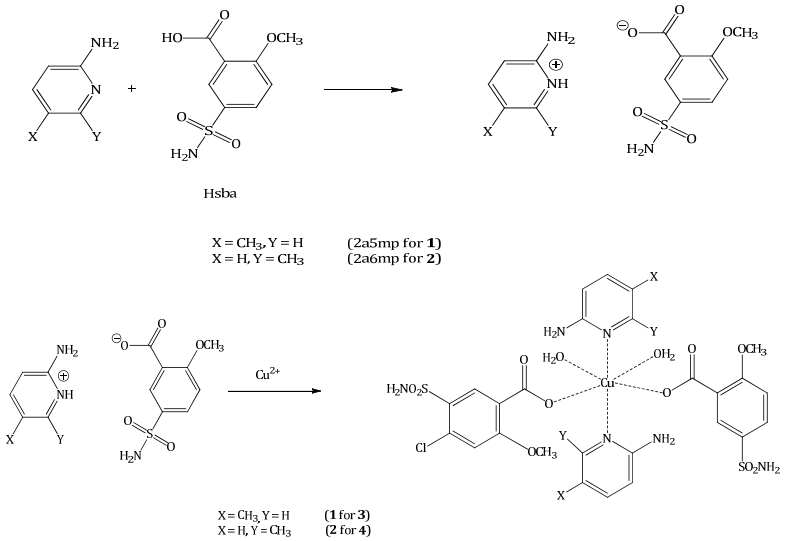


Figure 1. Syntheses of compounds 1-4 (a for 1 and 2, b for 3 and 4)

2.2. Anti-Microbial Assay

In this study, Eskişehir Osmangazi University's Faculty of Medicine provided the *E. faecalis* and *E. coli* bacteria utilized and the biology department of Eskişehir Technical University provided the *C. albicans*, *B. subtilis*, *L. monocytogenes*, *S. aureus* and *P. aeruginosa* microorganisms. All compounds had their anti-bacterial activity assessed using a microdilution susceptibility test. In dimethyl sulfoxide (DMSO) solution, the sample solutions had previously been separated.

The compounds' anti-bacterial investigation was conducted using a micro broth dilution susceptibility test. The samples' stock solutions in DMSO were created. In 4 mL of DMSO solution, synthesized substances (8 mg) and antibiotics (8 mg) were dissolved. Using McFarland No. 0.5 standard solution, overnight-grown bacterial and yeast suspensions in double-strength Mueller-Hinton broth were standardized to 10^8 Colony Forming Units/mL (CFU). The wells then received 100 µL of each microbe suspension. As a negative control, the last well chain without a microorganism was employed. The medium and sterile distilled water acted as a positive growth control. The first well without turbidity was chosen as the Minimum Inhibition Concentration (MIC) following an 18–24 h incubation period at 37 °C.

3. Results and Discussion

3.1. ^{1}H ve ^{13}C NMR Studies of 1 and 2.

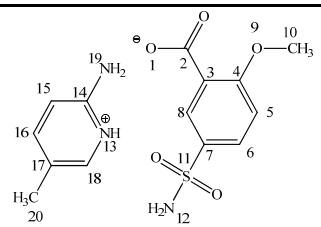
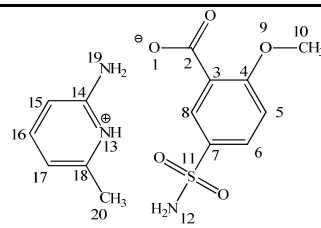
In ^{1}H ve ^{13}C NMR spectra and the chemical shift values of 1 and 2 are given Figures S1-S4, respectively, and Table 1.

In the ^{1}H NMR spectra of 1 and 2 (Figs S1 and S3), the protons of sba^- of 1 and 2 were observed 7.21 and 7.30 ppm (H^5, doublet, $^3J_{H5\text{-}H6}$ = 8.181 Hz for 1 and $^3J_{H5\text{-}H6}$ = 8.875 Hz for 2), 7.85 and 7.92 ppm (H^6, doublet $^3J_{H6\text{-}H5}$ = 7.867 Hz for 1, doublet-doublet $^3J_{H6\text{-}H5}$ = 8.807 Hz, $^4J_{H6\text{-}H8}$ = 2.487 Hz for 2), 8.04 and 8.10 ppm (H^8, singlet for 8, doublet $^4J_{H8\text{-}H6}$ = 2.459 Hz for 2) with 1H intensity, 3.85 and 3.90 ppm (H^{10}, singlet) with 3H intensity and 7.39 and 7.35 ppm (H^{12}, singlet) with 2H intensity, respectively. In protons of 2a5mp for 1 and 2a6mp for 2, were observed 7.39 ppm (1H, doublet, $^3J_{H15\text{-}H16}$ = 7.0175 Hz), 6.40 ppm (1H, doublet, $^3J_{H16\text{-}H15}$ = 7.089 Hz) and 7.70 ppm (1H, singlet) with 1H intensity for 1; 7.24 ppm (1H, doublet, $^4J_{H15\text{-}H17}$ = 0.494 Hz), 6.47 ppm (1H, doubletxdoublet, $^3J_{H17\text{-}H18}$ = 5.249 Hz, $^4J_{H17\text{-}H15}$ = 0.753 Hz) and 7.77 ppm (1H, doublet, $^3J_{H18\text{-}H17}$ = 4.896 Hz) with 1H intensity for 2. 6.12 and 6.08 ppm (H^{19}, singlet) with 2H intensity and 2.26+2.06 and 2.15 ppm (H^{20}, singlet) with 3H intensity for 1 and 2, respectively. H^{13} protons of 1 and 2 were not showed in spectra.

As expected, ^{13}C-NMR spectrum of 1 and 2 exhibits fourteen signals (Figs. S2 and S4, Table 1). The carbon signals of 1 and 2 were observed at 168.814 and 169.351 (C^2), 112.725 and 125.958 (C^3), 158.366 and 159.939 (C^4), 107.219 and 112.542 (C^5), 128.409 and 129.295 (C^6), 129.783 and 135.798 (C^7), 120.682 and 128.164 (C^8), 56.522 and 56.114 (C^{10}), 160.180 and 158.762 (C^{14}), 140.103 and 109.717 (C^{15}), 111.293 and 143.882 (C^{16}), 109.788 and 113.90 (C^{17}), 135.879 and 150.258 (C^{18}) and 22.105+17.233 and 43.643 (C^{20}) ppm for 7-9.

The ratio of Hsba and base (2a5mp and 2a6mp) was found to be 1:1 from the NMR spectra results of the salts (Fig. 1).

Table 1. ^{1}H-NMR results for compounds 1 and 2

							
1				**2**			
^{1}H-NMR		**^{13}C-NMR**		**^{1}H-NMR**		**^{13}C-NMR**	
H^{5}	7.21 (1H, d) [$^{3}J_{H5-H6}$ = 8.181 Hz]	C^{2}	168.814	H^{5}	7.30 (1H, d) [$^{3}J_{H5-H6}$ = 8.875 Hz]	C^{2}	169.351
H^{6}	7.85 (1H, d) [$^{3}J_{H6-H5}$ = 7.867 Hz]	C^{3}	112.725	H^{6}	7.92 (1H, dxd) [$^{3}J_{H6-H5}$ = 8.807 Hz, $^{4}J_{H6-H8}$ = 2.487 Hz]	C^{3}	125.958
H^{8}	8.04 (1H, s)	C^{4}	158.366	H^{8}	8.10 (1H, d) [$^{4}J_{H8-H6}$ = 2.459 Hz]	C^{4}	159.939
H^{10}	3.85 (3H, s)	C^{5}	107.219	H^{10}	3.90 (3H, s)	C^{5}	112.542
H^{12}	7.39 (2H, s)	C^{6}	128.409	H^{12}	7.35 (2H, s)	C^{6}	129.295
H^{13}	-	C^{7}	129.783	H^{13}	-	C^{7}	135.798
H^{15}	7.39 (1H, d) [$^{3}J_{H15-H16}$ = 7.0175 Hz]	C^{8}	120.682	H^{15}	7.24 (1H, d) [$^{4}J_{H15-H17}$ = 0.494 Hz]	C^{8}	128.164
H^{16}	6.40 (1H, d) [$^{3}J_{H16-H15}$ = 7.089 Hz]	C^{10}	56.522	H^{17}	6.47 (1H, dxd) [$^{3}J_{H17-H18}$ = 5.249 Hz, $^{4}J_{H17-H15}$ = 0.753 Hz]	C^{10}	56.114
H^{18}	7.70 (1H, s)	C^{14}	160.180	H^{18}	7.77 (1H, d) [$^{3}J_{H18-H17}$ = 4.896 Hz]	C^{14}	158.762
H^{19}	6.12 (2H, s)	C^{15}	140.103	H^{19}	6.08 (2H, s)	C^{15}	109.717
H^{20}	2.26 (2H, s) + 2.06 (1H, s)	C^{16}	111.293	H^{20}	2.15 (3H, s)	C^{16}	143.882
		C^{17}	109.788			C^{17}	113.90
		C^{18}	135.879			C^{18}	150.258
		C^{20}	22.105 17.233			C^{20}	43.643

3.2. IR Measurements

The IR data of the salts and Cu(II) complexes are given in Table 3 and Figs. S5-S8. The bands the ν(O-H) group of water molecules for 3 and 4 observed in the range of 3560-3581 cm^{-1}. The bands of NH_2 group of free ligands (Table 2) are slightly shifted from those found 3445, 3320 and 3220 cm^{-1} for 1, 3416, 3309 and 3199 cm^{-1} for 2, 3472, 3440, 3327 and 3202 cm^{-1} for 3 and 3469, 3328, 3266 and 3194 cm^{-1} for 4. The weak bands of ν(N^{+}-H) vibration for 1 and 2 observed at 2692-2514 cm^{-1} [22] while are not observed for 3 and 4 due to salt deprotonation during complex formation. Asymmetric (νas) and symmetrical (νs) stretch vibration wave numbers of carboxylate groups are given in Table 3. The difference in wave number (Δυ) shows how many teeth the group is attached to the metal. Δυ values for complexes 3 and 4 are 200 and 198, respectively, indicating monodentate binding of the carboxylate group to Cu(II) ion in the complexes [23]. It is seen in all compounds as the strong absorption bands in the range of 1641-1411 cm^{-1} for ν(C=N) and (C=C), 1378-1085 cm^{-1} for (C-O), 1373-1120 cm^{-1} for (S=O) and 822-768 cm^{-1} for pyridine groups. The weak vibration bands aromatic ν(C-H), aliphatic ν(C-H), ν(M-O) and ν(M-N) for 3 and 4 observed at 3082-3040 cm^{-1}, 3032-2765 cm^{-1}, 572 cm^{-1} and 497-432 cm^{-1}.

3.3. UV/Vis Measurements

The electronic spectra of all compounds were registered in DMSO ($1x10^{-3}$ *M*) (Table 4). Characteristic π-π^* and /n-π^* transitions are observed 302 and 291 nm for Hsba, 325 and 295 nm for 2a5mp, 321 and 308 nm for 2a6mp, 310 and 290 nm for 1, 300 and 289 nm for 2, 300 and 290 nm for 3 and 309 and 302 nm for 4. The d-d transitions for 3 and 4 are observed at 754 nm for 3 and 770 nm for 4.

Table 2. IR spectral data of all compounds (cm^{-1}).

	Hsba	2a5mp	2a6mp	1	2	3	4
ν(OH)	2900(br)			-	-	3560(br)	3581(br)
ν(N-H)	3425(m)	3387(m)	3175(m)	3445(m)	3416(m)	3472(m)	3469(m)
	3278(m)	3290(m)	3330(m)	3320(m)	3309(m)	3440(m)	3328(m)
					3199(m)	3327(m)	3266(m)
						3202(m)	3194(m)
$\nu(C\text{-}H)_{Ar}$	3090(w)	3092(w)	3040(m)	3079(w)	3044(w)	3072(w)	3075(w)
$\nu(CH)_{Alp.}$	2975(w)	3032(w)	2990(w)	2991(w)	2977(w)	2969(w)	2987(w)
	2835(w)	2989(w)	2870(w)	2951(w)	2953(w)	2938(w)	2900(w)
		2849(w)	2765(w)	2848(w)	2848(w)	2849(w)	2852(w)
$\nu(N^+H)$	-	-	-	2692(w)	2672(w)	-	-
				2514(w)	2594(w)		
ν(C=O)	1684(s)	-	-	1664(s)	1692(s)	1642(s)	1640(s)
						1442(s)	1442(s)
ν(C=N)	1430(s)	1585(s)	1571(s)	1622(s)	1641(s)	1610(s)	1608(s)
ν(C=C)	1401(s)	1475(s)	1465(s)	1585(s)	1601(s)	1580(s)	1581(s)
		1447(s)	1443(s)	1557(s)	1578(s)	1514(s)	1561(s)
		1417(s)		1478(s)	1543(s)	1485(s)	1497(s)
				1443(s)	1490(s)	1460(s)	1467(s)
				1411(s)	1469(s)		
ν(C-O)	1352(s)	-	-	1364(s)	1378(s)	1375(s)	1375(s)
	1250(s)			1258(s)	1273(s)	1295(s)	1295(s)
	1169(s)			1086(s)	1085(s)	1091(s)	1091(s)
ν(S=O)	1373(s)	-	-	1327(s)	1333(s)	1277(s)	1277(s)
	1160(s)			1164(s)	1171(s)	1170(s)	1171(s)
				1120(s)	1123(s)	1126(s)	1125(s)
ν(py)	-	791(s)	795(s)	782(s)	794(s)	822(s)	768(s)
ν(M-O)	-	-	-	-	-	572(w)	572(w)
ν(M-N)	-	-	-	-	-	497(w)	436(w)

Table 3. Optical properties all compounds in DMSO ($nm(Lmol^{-1}cm^{-1})$)

Hsba	2a5mp	2a6mp	1	2	3	4
302(32160)	313(32610)	309(33120)	310(33850)	300(13550)	754(320)	770(320)
291(26530)		291(26230)	290(25280)	289(13060)	300(41190)	309(43400)
					290(31540)	302(48170)

3.4. Magnetic Susceptibility Measurements

Magnetic susceptibility results of Cu(II) complexes (3 and 4) were found 1.65 BM. These values say that there are unpaired electrons in the complexes.

3.5. Anti-Microbial Activity Results

The anti-microbial activity of anti-microbial agents, $Cu(OAc)_2.2H_2O$, Hsba, 2a5mp, 2a6mp and 1-4 were investigated by microdilution method. All compounds showed activity against bacteria and yeast. MIC values of anti-microbial all compounds are given in Table 4. Activity values are similar to 2-aminopyridines found in the literature [11-13,15-18].

The anti-fungal drug and substances have activity against *C. albicans* when MIC values are compared; $Cu(OAc)_2.2H_2O$, 2 and 4 (31.25 µg/mL) observed greater activity than according to Fluconazole while 2a5mp and 2a6mp showed equal effective (62.50 µg/mL). Other compounds were found to have a lower degree of action (125.00 µg/mL).

All anti-bacterial drugs and substances have activity against *L. monocytogenes*; when MIC values are compared; all compounds indicated greater activity than according to Vancomycin (125.00 µg/mL) {Hsba and 3 (31.25 µg/mL) > $Cu(OAc)_2.2H_2O$, 2a5mp, 2a6mp, 1, 2 and 4 (62.50 µg/mL)}. Hsba and 3 showed equal activity (31.25 µg/mL) according to Levofloxacin and Cefepime while indicated less activity other compounds (62.50 µg/mL).

B. subtilis; all compounds showed greater activity than according to Vancomycin (250.00 µg/mL) {2a5mp (7.80 µg/mL) > 1 and 2 (31.25 µg/mL) > $Cu(OAc)_2.2H_2O$, Hsba, 2a6mp, 3 and 4 (62.50 µg/mL)}. 2a5mp (7.80 µg/mL), 1 and 2 (31.25 µg/mL) showed greater activity than according to Levofloxacin and Cefepime while $Cu(OAc)_2.2H_2O$, Hsba, 2a6mp, 3 and 4 showed equally effective (62.50 µg/mL).

Table 4. MIC results of the compounds (µg/mL)

	C. albicans	***L. monocytogenes***	***B. subtilis***	***E. coli***	***S. aureus***	***E. faecalis***	***P. aeruginosa***
Vancomycin	-	125.00	250	31.25	31.25	62.50	62.50
Levofloxacin	-	31.25	62.50	31.25	31.25	62.50	31.25
Cefepime	-	31.25	62.50	62.50	62.50	31.25	31.25
Fluconazole	62.50	-	-	-	-	-	-
$Cu(OAc)_2$	31.25	62.50	62.50	62.50	31.25	62.50	62.50
Hsba	125.00	31.25	62.50	125.00	125.00	125.00	31.25
2a5mp	62.50	62.50	7.80	62.50	62.50	62.50	62.50
2a6mp	62.50	62.50	62.50	62.50	62.50	62.50	125.00
1	62.50	62.50	31.25	62.50	31.25	31.25	62.50
2	31.25	62.50	31.25	125.00	62.50	62.50	62.50
3	125.00	31.25	62.50	62.50	62.50	62.50	31.25
4	31.25	62.50	62.50	62.50	62.50	62.50	62.50

E. coli; Hsba and 2 (125.00 µg/mL) were found to have a lower degree according to Cefepime while $Cu(OAc)_2.2H_2O$, 2a5mp, 2a6mp, 1, 3 and 4 showed similar effective (62.50 µg/mL). The all compounds seen lower degree of according to Vancomycin and Levofloxacin.

S. aureus; the other compounds found to have a lower degree according to Vancomycin and Levofloxacin while $Cu(OAc)_2.2H_2O$ and 1 showed equally effective (31.25 µg/mL). $Cu(OAc)_2.2H_2O$ and 1 (31.25 µg/mL) showed greater activity than according to Cefepime while 2a5mp, 2a6mp and 2-4 (62.50 µg/mL) showed equally effective.

E. faecalis; 1 (31.25 µg/mL) observed similar activity according to Cefepime while other compounds seen less level of activity {$Cu(OAc)_2.2H_2O$, 2a5mp, 2a6mp and 2-4 (62.50 µg/mL) > Hsba (125.00 µg/mL)}. 1 (31.25 µg/mL) showed greater activity than according

to Vancomycin and Levofloxacin while $Cu(OAc)_2.2H_2O$, 2a5mp, 2a6mp and 2-4 showed equally effective (62.50 µg/mL. Compounds Hsba were found to have a lower degree of according to Vancomycin and Levofloxacin.

P. aeruginosa; Hsba and 3 (31.25 µg/mL) showed greater activity than according to Vancomycin while $Cu(OAc)_2.2H_2O$, 2a5mp, 1, 2 and 4 equally effective (62.50 µg/mL). 2a6mp (125.00 µg/mL) were found to have a lower degree of according to Vancomycin. Other compounds were found to have a lower degree according to Cefepime and Levofloxacin while Hsba and 3 showed equally effective (31.25 µg/mL).

4. Conclusions

In this study, two new salts (1 and 2) obtained between 2-methoxy-5-sulfamoylbenzoic acid (Hsba) and 2-amino-X-picoline {X = 5 (2a5mp) and 6 (2a6mp)} and their Cu(II) complexes (3 and 4) have been obtained. The structures of the salts (1 and 2) were suggested by elemental analysis, NMR, FT-IR and UV-Vis, while the structures of Cu(II) complexes (3 and 4) were suggested by elemental analysis, AAS, UV-Vis and magnetic susceptibility techniques. While the acid:base ratio was 1:1 for 1 and 2 salts, the metal:acid:base ratio was 1:2:2 for 3 and 4. All compounds showed activity against bacteria and yeast. *Compounds* $Cu(OAc)_2.2H_2O$, 2 and 4 (31.25 µg/mL) for *C. albicans*, Hsba and 3 (31.25 µg/mL) for *L. monocytogenes*, 2a5mp (7.80 µg/mL) for *B. subtilis,* all compounds (except Hsba and 2) (62.50 µg/mL) for *E. coli*, Hsba (31.25 µg/mL) for *S. aureus*, 1 (31.25 µg/mL) for *E. faecalis* and Hsba and 3 (15.60 µg/mL) for *P. aeruginosa have the best activity.*

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Conflict of Interest

The authors declare no conflict of interest.

Author Contribution

Authors contributed equally to this work.

Ethics Consent

Ethics committee approval is not required for this article.

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Appendix

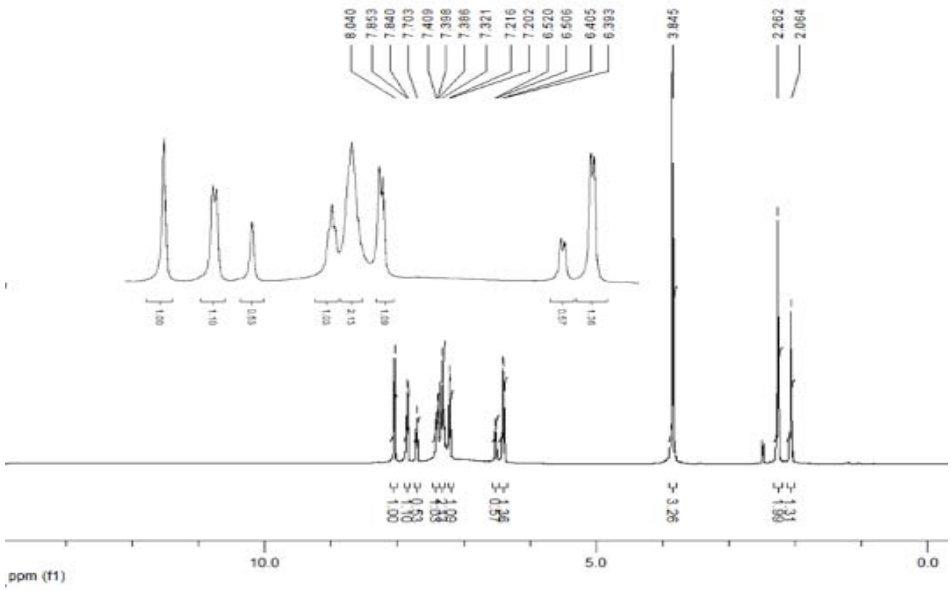

Figure S1. ^{1}H NMR spectra of compound 1.

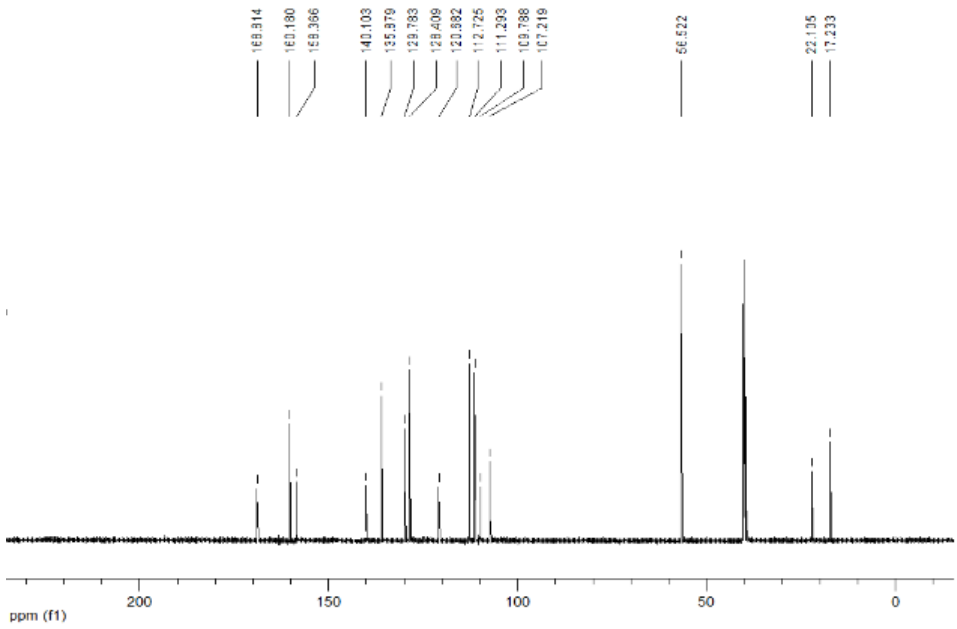

Figure S2. ^{13}C NMR spectra of compound 1.

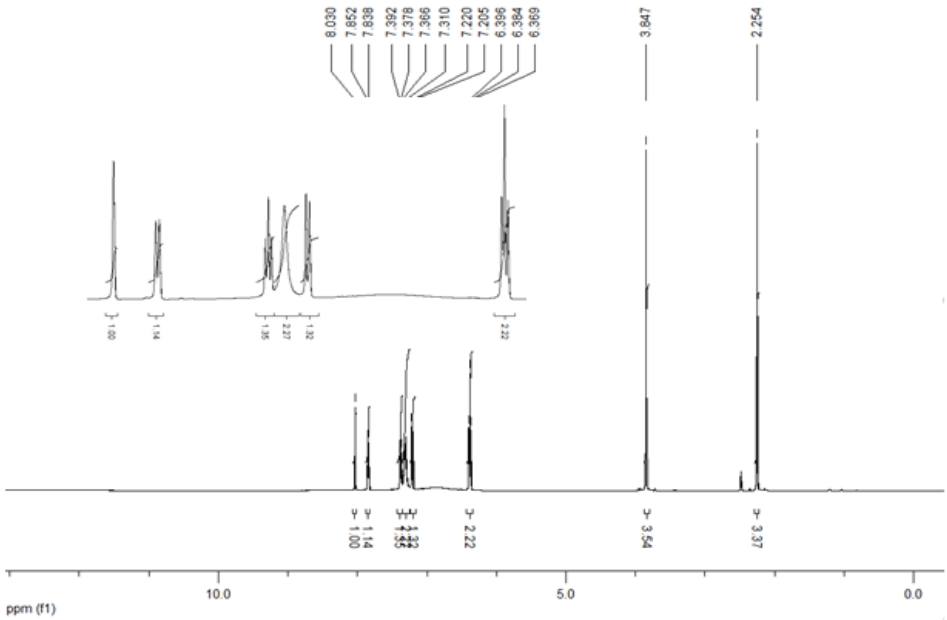

Figure S3. ^{1}H NMR spectra of compound 2.

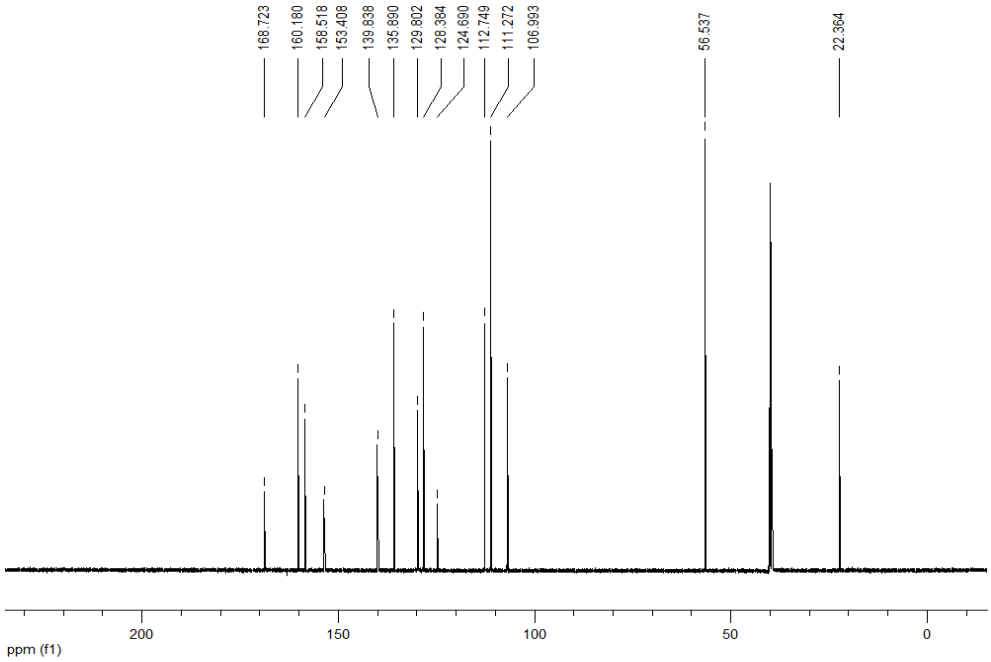

Figure S4. ^{13}C NMR spectra of compound 2.

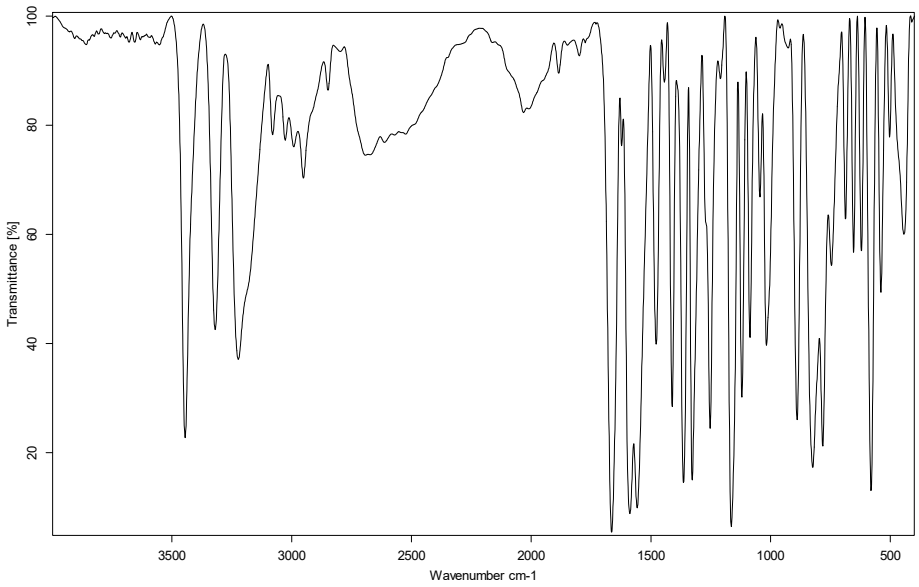

Figure S5. IR spectrum of 1.

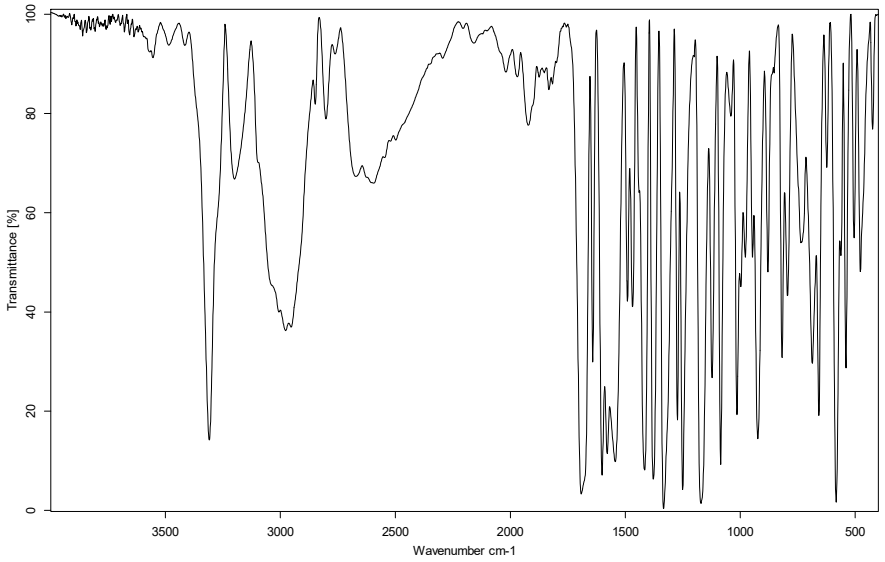

Figure S6. IR spectrum of 2.

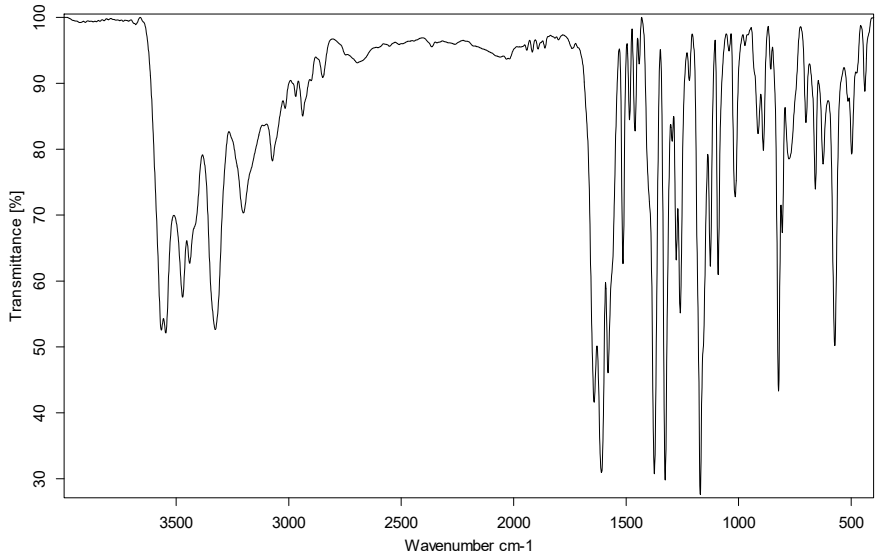

Figure S7. IR spectrum of 3.

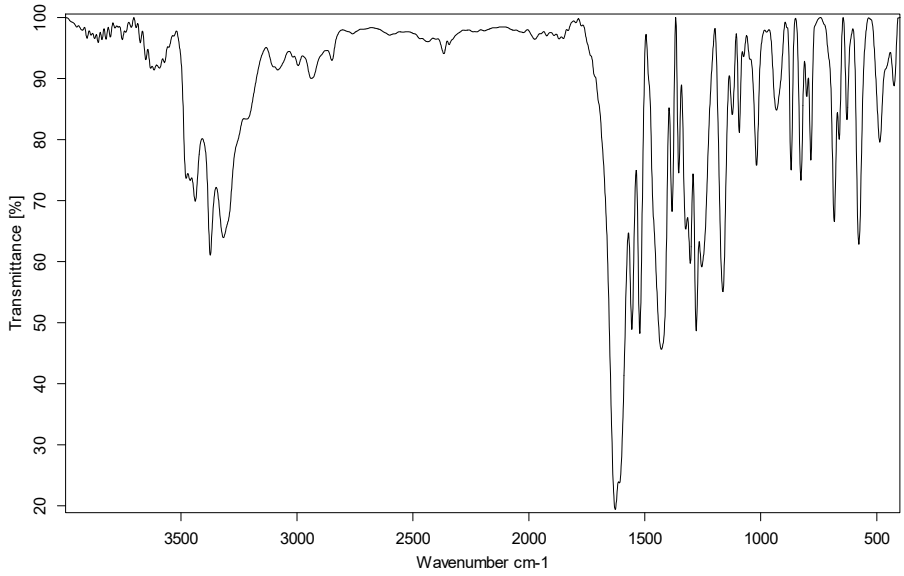

Figure S8. IR spectrum of 4.