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# Synthesis, characterization, and antibacterial studies of pipemidic acid metal complexes

Ahsan Zamir Siddiqi<sup>1,2</sup> and Agha Zeeshan Mirza<sup>3\*</sup>

## Abstract

**Background:** Pipemidic acid, like other quinolones, is susceptible against different organisms in vitro, and it was proved to be a preferred choice for certain indications. Previous studies reveal that concurrent administration of essential and trace elements with quinolones decreases gastrointestinal absorption, causing therapeutic failure. To study the probable interaction of pipemidic acid with essential and trace elements present in the human body, pipemidic acid has been reacted with magnesium, calcium, chromium, manganese, iron, cobalt, nickel, copper, zinc, and cadmium, the complexes formed.

**Results:** The compounds were characterized by the melting point, conductance studies, IR, UV, <sup>1</sup>H-NMR, CHN, and atomic absorption analysis.

**Conclusion:** The results suggested oxygen atoms present at carbonyl and carboxylic group render the bidentate property to the pipemidic acid. The antimicrobial activity of the compounds was determined by the disk diffusion method, and both standard and complexes show no antibacterial activity against the clinical isolates.

**Keywords:** Pipemidic acid, Metal complexes, Antibacterial studies

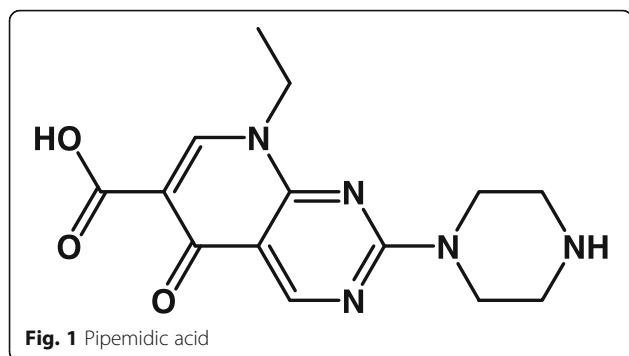
## Background

Pipemidic acid (Fig. 1), an antibacterial agent [1], is found to be susceptible against different species of *Escherichia*, *Proteus*, *Morganella*, *Citrobacter*, *Klebsiella*, *Enterobacter*, *Serratia*, *Pseudomonas aeruginosa*, *Pseudomonas cepacia*, and other non-fermenting Gram-negative bacteria, while both *Staphylococcus aureus* and *Staphylococcus epidermidis* were 2 to 3 times less frequently susceptible to pipemidic acid and nalidixic acid than to norfloxacin and ofloxacin [2–4]. Pipemidic acid has an excellent inhibitory effect on caffeine by concomitant administration of pipemidic acid [5, 6]. Staib et al. [7] reported that pipemidic acid has markedly inhibited theophylline clearance. Pipemidic acid and its complexes have inhibitory action against *Escherichia*

*coli*, *Bacillus subtilis*, *Streptococcus pneumonia*, and *Pseudomonas aeruginosa* [8]. It is also showed some activity against Gram-positive bacteria. The basic piperazine ring, which can form the zwitterionic nature with the carboxylic acid at the C3-position, has subsequently been shown to increase the ability of the drugs to penetrate the bacterial cells resulting in enhanced activity. Further, the zwitterionic forms resulted in significant tissue penetration in pharmacokinetics [9]. Pipemidic acid is useful in different infections and inflammatory diseases as well as for prophylactic purposes. It is useful for infectious inflammatory diseases of the kidney, urinary tract, and prostate when given for 10 days twice daily in a dose of 400 mg and has high efficacy against both Gram-negative and Gram-positive bacteria [10]. The interaction of metals with the drugs has significance in biological processes and drug effectiveness reliant on coordination with metals in many cases. The complexes of pipemidic acid with Ca<sup>2+</sup>, Sr<sup>2+</sup>, Ba<sup>2+</sup>, Sn(IV) [11] and

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with  $\text{VO}^{2+}$ ,  $\text{Mn}^{2+}$ ,  $\text{Fe}^{3+}$ ,  $\text{Co}^{2+}$ ,  $\text{Ni}^{2+}$ ,  $\text{Zn}^{2+}$ ,  $\text{MoO}_2^{2+}$ ,  $\text{Cd}^{2+}$ , and  $\text{UO}_2^{2+}$  are reported, and by utilizing the oxygen and carboxylate oxygen, it acts as a bidentate ligand [12]. In this paper, the synthesis and characterization of the complexes formed from the reaction of pipemidic acid with Mg(II), Ca(II), Cr(II), Mn(II), Fe(III), Co(II), Ni(II), Cu(II), Zn(II), and Cd(II) salts are reported and the comparative study of the effect of antibacterial activity of metal complexes against Gram-positive and Gram-negative strain of microorganisms.

## Method

### Materials

Pipemidic acid was kindly provided by Abbott Laboratories Pakistan. The essential and trace elements were used in the form of the following hydrated salts: magnesium chloride hexahydrate ( $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ ), calcium chloride dihydrate ( $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ ), chromium chloride hexahydrate ( $\text{CrCl}_3 \cdot 6\text{H}_2\text{O}$ ), manganese chloride monohydrate ( $\text{MnCl}_2 \cdot \text{H}_2\text{O}$ ), ferric chloride hexahydrate ( $\text{FeCl}_3 \cdot 6\text{H}_2\text{O}$ ), cobalt chloride hexahydrate ( $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$ ), nickel chloride hexahydrate ( $\text{NiCl}_2 \cdot 6\text{H}_2\text{O}$ ), copper chloride dihydrate ( $\text{CuCl}_2 \cdot 2\text{H}_2\text{O}$ ), zinc chloride ( $\text{ZnCl}_2$ ), and cadmium chloride monohydrate ( $\text{CdCl}_2 \cdot \text{H}_2\text{O}$ ). Analytical grade methanol was used as a solvent.

### Synthesis

The reported methods were used with slight modification [13, 14]. Pipemidic acid trihydrate was dissolved in a little amount of DMF (~5 mL), methanol was added (20 mL), and a solution of the metal in warm methanol (10 mL) was added with constant stirring. This solution was refluxed for 3 h and allowed to stand for crystallization at room temperature. Crystals obtained after 48 h were filtered and washed with methanol and dried. The melting point of these complexes was recorded on a Gallenkamp apparatus. The conductance of the complexes was measured by dissolving 0.003 g of the complex in 10 mL of distilled water. At the same time, the conductivity meter was calibrated with the help of 0.1 M potassium chloride solution. These compounds were characterized by an IR spectrophotometer (Perkin

Elmer 1310 USA) in the region of 600–4000  $\text{cm}^{-1}$ . Spectrophotometric measurements were performed in the aqueous solution on a UV-visible (Shimadzu 240) spectrophotometer. Proton NMR studies were carried out on a Bruker instrument in deuterated water using TMS as an internal standard. Elemental analysis of carbon, hydrogen, and nitrogen was also employed using standard micro methods on Carlo Erba 1106. Metals were estimated on a Pye-Unicam atomic absorption spectrophotometer to determine the ratio of drug metal complexation.

## Results

### Spectral data

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Mg}$ : colour, light brown; mp 280d; IR; 1620 b (C=O), 1734 m (C=O, ketone group), 2990 m (NH); 3400 m (OH stretch);  $^1\text{H}$  NMR; 1.27 ( $\text{CH}_3$ , ethyl group),  $\delta$ : 2.54 ( $\text{CH}_2$ , ethyl group), 2.79 and 3.30 (2  $\text{CH}_2$  of piperazinyl group), 3.88 (H, ring position 5), 8.87 (H, ring position 2), 9.51 (H, carboxylic group); C; H; N found: C 53.34; H 5.40; N 22.26; M 3.85.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Ca}$ : colour, off white; mp 278d; IR; 1619 s (C=O), 1735 s (C=O, ketone group), 2995 m (NH), 3420 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.34 ( $\text{CH}_3$ , ethyl group), 2.47 ( $\text{CH}_2$ , ethyl group), 2.84 and 3.32 (2  $\text{CH}_2$  of piperazinyl group), 3.93 (H, ring position 5), 8.84 (H, ring position 2), 9.45 (H, carboxylic group); C; H; N found: C 52.05; H 5.26; N 21.73; M 6.21.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Cr}$ : colour, greenish brown; mp 282d; IR; 1610 s (C=O), 1729 s (C=O, ketone group), 2985 m (NH), 3430 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.29 ( $\text{CH}_3$ , ethyl group), 2.58 ( $\text{CH}_2$ , ethyl group), 2.87 and 3.27 (2  $\text{CH}_2$  of piperazinyl group), 3.90 (H, ring position 5), 8.82 (H, ring position 2), 9.48 (H, carboxylic group); C; H; N found: C 51.11; H 5.23; N 21.35; M 7.88.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Mn}$ : colour, light yellow; mp 274d; IR; 1612 b (C=O), 1732 sm (C=O, ketone group), 2983 m (NH), 3420 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.31 ( $\text{CH}_3$ , ethyl group), 2.56 ( $\text{CH}_2$ , ethyl group), 2.81 and 3.28 (2  $\text{CH}_2$  of piperazinyl group), 3.84 (H, ring position 5), 8.91 (H, ring position 2), 9.50 (H, carboxylic group); C; H; N found: C 50.79; H 5.22; N 21.21; M 8.31.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Fe}$ : colour, orange; mp 220d; IR; 1605–1630 b (C=O), 1730 sm (C=O, ketone group), 2995 m (NH), 3440 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.28 ( $\text{CH}_3$ , ethyl group), 2.53 ( $\text{CH}_2$ , ethyl group), 2.81 and 3.28 (2  $\text{CH}_2$  of piperazinyl group), 3.84 (H, ring position 5), 8.91 (H, ring position 2), 9.50 (H, carboxylic group); C; H; N found: C 50.80; H 5.23; N 21.20; M 8.43.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Co}$ : colour, light blue; mp 272d; IR; 1620 b (C=O), 1732 m (C=O, ketone group), 2983 m (NH), 3410 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.33 ( $\text{CH}_3$ , ethyl group), 2.48 ( $\text{CH}_2$ , ethyl group), 2.82 and 3.31 (2  $\text{CH}_2$  of piperazinyl group), 3.88 (H, ring position 5), 8.94 (H,

**Table 1** Physical characteristics of pipemidic acid metal complex

Drug complexed	Colour	Conductance $\mu\text{s}/\text{cm}$	M.P $^{\circ}\text{C}$	Change in $\epsilon$ ( $\lambda_{\text{max}}$ )	
Ref. drug	Pale yellow	57.1	252	39160 (274)	12269 (314)
				11575 (330)	
Magnesium	Light brown	97.9	280d	36504 (276)	11393 (316)
Calcium	Off white	98.3	278d	35078 (276)	11256 (317)
Chromium	Greenish brown	109.1	282d	26197 (283)	10998 (335)
Manganese	Light yellow	90.9	274d	37687 (277)	11791 (316)
Iron	Orange	89.4	220d	31315 (276)	10136 (317)
Cobalt	Light blue	114.8	272d	29710 (277)	9265 (316)
Nickel	Greenish white	94.6	288d	49675 (277)	15810 (316)
Copper	Brown	118.7	230	39111 (277)	12143 (317)
Zinc	Off white	128	278d	38184 (277)	11952 (316)
Cadmium	White	111.2	266	33347 (277)	10677 (316)

ring position 2), 9.46 (H, carboxylic group); C; H; N found: C 50.50; H 5.20; N 21.06; M 8.88.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Ni}$ : colour, greenish white; mp 288d; IR; 1613 s (C=O), 1725 m (C=O, ketone group), 2985 m (NH), 3390 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.29 ( $\text{CH}_3$ , ethyl group), 2.53 ( $\text{CH}_2$ , ethyl group), 2.87 and 3.32 (2  $\text{CH}_2$  of piperazinyl group), 3.89 (H, ring position 5), 8.90 (H, ring position 2), 9.49 (H, carboxylic group); C; H; N found: C 50.65; H 5.19; N 21.01; M 8.83.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Cu}$ : colour, brown; mp 230; IR; 1605 m (C=O), 1724 m (C=O, ketone group), 2990 m (NH), 3380 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.34 ( $\text{CH}_3$ , ethyl group), 2.49 ( $\text{CH}_2$ , ethyl group), 2.87 and 3.30 (2  $\text{CH}_2$  of piperazinyl group), 4.0 (H, ring position 5), 8.96 (H, ring position 2), 9.56 (H, carboxylic group); C; H; N found: C 50.11; H 5.15; N 20.83; M 9.50.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Zn}$ : colour, off white; mp 278d; IR; 1618 m (C=O), 1730 m (C=O, ketone group), 2985 m (NH),

3420 m (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.36 ( $\text{CH}_3$ , ethyl group), 2.57 ( $\text{CH}_2$ , ethyl group), 2.85 and 3.26 (2  $\text{CH}_2$  of piperazinyl group), 3.82 (H, ring position 5), 8.85 (H, ring position 2), 9.53 (H, carboxylic group); C; H; N found: C 50.10; H 5.12; N 20.90; M 9.72.

$\text{C}_{28}\text{H}_{34}\text{N}_{10}\text{O}_6\text{Cd}$ : colour, white; mp 266; IR; 1600 b (C=O), 1720 m (C=O, ketone group), 2980 m (NH), 3440 b (OH stretch);  $^1\text{H}$  NMR;  $\delta$ : 1.31 ( $\text{CH}_3$ , ethyl group), 2.55 ( $\text{CH}_2$ , ethyl group), 2.80 and 3.29 (2  $\text{CH}_2$  of piperazinyl group), 3.92 (H, ring position 5), 8.89 (H, ring position 2), 9.59 (H, carboxylic group); C; H; N found: C 46.71; H 4.74; N 19.53; M 15.62.

#### Antibacterial studies

Antibacterial studies of pipemidic acid metal complexes against Gram-positive and Gram-negative organisms, such as *Klebsiella Pneumoniae*, *Proteus mirabilis*, *Staphylococcus aureus*, *Corynebacterium hoffmanni*,

**Table 2** Infrared absorption bands shifting of pipemidic acid metal complexation

Drug complex with	O–H stretch	Carboxylic acid C = O	Pyridone ring C = O (ketone)
Reported drug	3465	1640	1619
Ref. drug	3460 b	1640 m	1620 m
Magnesium	3400 m	1620 b	1734 m
Calcium	3420 b	1619 s	1735 s
Chromium	3430 b	1610 s	1729 s
Manganese	3420 b	1612 b	1732 sm
Iron	3440 b	1605–1630 b	1730 sm
Cobalt	3410 b	1620 b	1732 m
Nickel	3390 b	1613 s	1725 m
Copper	3380 b	1605 m	1724 m
Zinc	3420 b	1618 m	1730 m
Cadmium	3440 b	1600 b	1720 s

b broad, m medium, s small

**Table 3** Proton NMR assignments of pipemidic acid and its metal complexes

Drug complexed with	Ethyl group		Piperazinyl group		Ring proton of position 2	Ring proton of position 5	Carboxylic
	CH <sub>2</sub>	CH <sub>3</sub>	CH <sub>2</sub>	CH <sub>2</sub>			
Reference drug	2.47	1.34	2.77	3.33	8.94	3.81	9.17
Magnesium	2.54	1.27	2.79	3.30	8.87	3.88	9.51
Calcium	2.47	1.34	2.84	3.32	8.84	3.93	9.45
Chromium	2.58	1.29	2.87	3.27	8.82	3.90	9.48
Manganese	2.56	1.31	2.81	3.28	8.91	3.84	9.50
Iron	2.53	1.28	2.84	3.27	8.87	3.87	9.52
Cobalt	2.48	1.33	2.82	3.31	8.94	3.88	9.46
Nickel	2.53	1.29	2.87	3.32	8.90	3.89	9.49
Copper	2.49	1.34	2.87	3.30	8.96	4.00	9.56
Zinc	2.57	1.36	2.85	3.26	8.85	3.82	9.53
Cadmium	2.55	1.31	2.80	3.29	8.89	3.92	9.59

*Klebsiella species*, *Shigella dysentery*, *Streptococcus faecalis*, *Corynebacterium diphtheria*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Bacillus species*, *Citrobacter species*, *Salmonella typhi*, and *Streptococcus pyogenes* were carried out by disk susceptibility technique. The diffusion technique, according to FDA, was followed used widely in clinical laboratories [15–17].

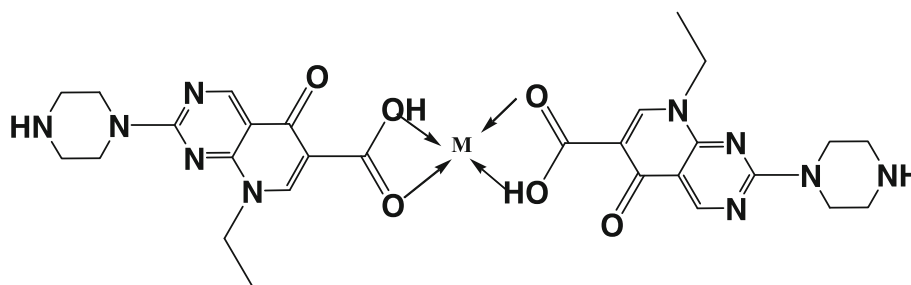
## Discussion

The solubility of pipemidic acid complexes was checked in different solvents; all complexes were stable at room temperature and were soluble in water. The conductance of all complexes was then measured by dissolving 3 mg of complexes in 10 mL water; pipemidic acid was also prepared in the same manner having 24  $\mu\text{s}/\text{cm}$ . The conductance of all metal complexes markedly increased compared to the reference drug. The melting point of reference drugs and complexes was also studied. Pipemidic acid reference standard was melted at 252 °C, but most of its metal complexes were decomposed. The physical characteristics of pipemidic acid and its metal complexes are shown in Table 1.

## IR spectroscopy

IR spectrum of the pipemidic acid showed two strong bands at 1619  $\text{cm}^{-1}$  and 1640  $\text{cm}^{-1}$ , which were assigned to the stretching vibration of the carboxylic carbonyl group and ring carbonyl group, respectively [18], whereas in our spectra of pipemidic acid for CO of carboxylic carbonyl group was found at 1620  $\text{cm}^{-1}$  as the medium peak, CO of the ring carbonyl group (ketone) lied at 1640  $\text{cm}^{-1}$ , and for OH, the absorption was at 3460  $\text{cm}^{-1}$  as a medium peak. Lin et al. [18] reported complexes of pipemidic acid with rare earth metals. They found a 1717–1737  $\text{cm}^{-1}$  band, which shows the coordination of metal ions with OH of the carboxylic group. The shift to a higher frequency of carboxylic group takes place due to complexation with water of crystallization. The C=O ring and OH in the carboxylic group were shifted to a lower frequency, and the same results were obtained in our studies of all metal complexes with pipemidic acid.

In all metal complexes, the peak of the carboxylic group was shifted to a higher frequency. In magnesium, cobalt, nickel, copper, and zinc, the peak shift was observed between 1724 and 1734  $\text{cm}^{-1}$  as a medium peak

**Fig. 2** Metal complexes of pipemidic acid

**Table 4** Elemental analysis and metal estimation of pipemidic acid and its metal complexes

Empirical formula (formula weight)	%C	%H	%N	%Metal
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> (606.64)	55.54	5.65	23.09	0.00
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Mg (630.95)	53.34 (53.31)	5.40 (5.44)	22.26 (22.22)	3.85 (3.81)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Ca (646.72)	52.05 (51.99)	5.26 (5.30)	21.73 (21.67)	6.21 (6.18)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Cr (658.64)	51.11 (51.06)	5.23 (5.20)	21.35 (21.27)	7.88 (7.89)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Mn (661.58)	50.79 (50.83)	5.22 (5.18)	21.21 (21.17)	8.31 (8.30)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Fe (662.49)	50.80 (50.76)	5.23 (5.17)	21.20 (21.14)	8.43 (8.43)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Co (665.57)	50.50 (50.53)	5.20 (5.15)	21.06 (21.04)	8.88 (8.85)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Ni (665.33)	50.65 (50.55)	5.19 (5.15)	21.01 (21.05)	8.83 (8.82)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Cu (670.19)	50.11 (50.18)	5.15 (5.11)	20.83 (20.90)	9.50 (9.48)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Zn (672.02)	50.10 (50.04)	5.12 (5.10)	20.90 (20.84)	9.72 (9.73)
C <sub>28</sub> H <sub>34</sub> N <sub>10</sub> O <sub>6</sub> Cd (719.05)	46.71 (46.77)	4.74 (4.77)	19.53 (19.48)	15.62 (15.63)
(Expected)				

whereas in manganese and iron, it occurred as a small peak at 1730 and 1732 cm<sup>-1</sup>, respectively. The calcium, chromium, and cadmium showed sharp peaks in the region between 1720 and 1735 cm<sup>-1</sup>.

For the carboxylic ring group, the peaks of all metal complexes shifted towards lower wavenumber that are calcium, chromium, and nickel recorded as a sharp peak in the region of 1610–1619 cm<sup>-1</sup>, while in magnesium, manganese, iron, cobalt, and cadmium broad bands were obtained in the region 1600–1630 cm<sup>-1</sup>. Copper and zinc showed medium peaks at 1605 and 1618 cm<sup>-1</sup>, respectively (Table 2). The formation of the bidentate ligand with metal ion coordinate with the oxygen of carbonyl ring and oxygen of the hydroxyl group is evident from these results [19].

#### UV/visible spectrophotometric studies

Pipemidic acid and its metal complexes were dissolved in distilled water and scan in the range of 200 to 700 nm. Both bathochromic and hypsochromic shifts were found in the spectra, with the bands at 268 and 329 nm shifted to 270 and 327 nm, respectively. A similar type of results obtained in another study. Marija et al. [19] compared the spectra of ciprofloxacin and ciprofloxacin zinc

complex in the same solvent, in the presence of zinc ions, and both bathochromic and hypsochromic shifts were found. This proposes the complexation between the drug and metal.

#### NMR studies

Table 3 shows the NMR data of pipemidic acid and its metal complexes. The ethyl group peaks of protons were at 1.34 and 2.47 ppm in the standard spectra of pipemidic acid. Peaks of piperazinyl protons were found at 2.77 and 3.33 ppm, while the proton of the pyridone ring was at 8.94 ppm. Protons of ring adjacent to pyridone were at 3.81 ppm and carboxylic proton at 9.17 ppm. In a comparison of main peaks of pipemidic acid with metal complexes, it was concluded that all other groups showed a set of signals that were almost similar except for carboxylic moiety that took part in bonding with metal shown by a downfield of signals indicative of its participation in bonding with a metal ion ([supplementary information](#)).

#### Atomic absorption and elemental analysis studies

Estimation of pipemidic acid and its complexes were carried out by using the Pye-Unicam atomic absorption spectrometer. The expected percentage of magnesium in pipemidic acid magnesium complex for 1:1 ratio was 6.83%, for 2:1 ratio 3.85%, and for 4:1 ratio 1.96% while according to the experimental results, the percentage calculated was 3.86% which is nearest to the expected value of 2:1 ratio, showing that the drug and metal are bonded in the ratio of 2:1 (Fig. 2). Similar results were obtained in all complexes establishing that the drug and metal are bound together in the ratio of 2:1. Table 4 shows the data of the elemental analysis of the drug metal complex.

#### Antibacterial activity

All of these organisms were tested against pipemidic acid metal complexes, and both standard and complexes show no activity against a few microorganisms [18] or similar antibacterial activity against the clinical isolates as compared to the standard drug as reported earlier [12], which illustrates a clear picture that older quinolone is outdated as compared to the new generation of quinolone.

#### Conclusion

The differences in the colour, conductance value, and the change in melting points of these complexes suggested that a new product has been formed. The characterization studies of drug and metal complexes included IR, and <sup>1</sup>H-NMR spectroscopic techniques, elemental analysis, and AA spectroscopy suggested the structure of complexes. The shifts in the peaks of the IR

region as well in the  $^1\text{H-NMR}$  studies confirmed the presence of drug metal complexation. The resulting complexes are showing that the drug and metal are bonded with a 2:1 ratio.

#### Abbreviations

IR: Infrared; UV: Ultraviolet;  $^1\text{H-NMR}$ : Hydrogen-nuclear magnetic resonance; CHN analysis: Carbon hydrogen nitrogen analysis

#### Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s43094-021-00301-8>.

#### Additional file 1.

#### Acknowledgements

Not applicable.

#### Authors' contributions

AZS: design, performed the experiment, writing of the project. AZM: help in writing and supervising the project. All authors have read and approved the manuscript.

#### Funding

No funding received for this work.

#### Availability of data and materials

Data and materials are available upon request.

#### Declarations

#### Ethics approval and consent to participate

Not applicable.

#### Consent for publication

Not applicable.

#### Competing interests

No competing interests have been reported for the manuscript.

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Received: 31 March 2021 Accepted: 5 July 2021

Published online: 23 July 2021

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