Journal of Coordination Chemistry
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gcoo20

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Accepted author version posted online: 02 Jul 2012.Published online: 17 Jul 2012.

To cite this article: Mehdi Salehi , Reza Kia & Ali Khaleghian (2012) Syntheses, crystal structures, and antibacterial activities of two cobalt(III) complexes, Journal of Coordination Chemistry, 65:17, 3007-3018, DOI: 10.1080/00958972.2012.708737

To link to this article: http://dx.doi.org/10.1080/00958972.2012.708737

Journal of Coordination Chemistry
Vol. 65, No. 17, 10 September 2012, 3007–3018

Syntheses, crystal structures, and antibacterial activities of two cobalt(III) complexes

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(*Received 25 January 2012; in final form 25 May 2012*)

Syntheses, structures, and antimicrobial activities of cobalt(III) complexes with two tetradentate Schiff-base ligands, $(BA)_2en$ = bis(benzoylacetone)ethylenediimine dianion and $(acac)_2en$ = bis(acetylacetone)ethylenediimine dianion, and two axial pyridines (py) have been investigated. These complexes were characterized by FT-IR, ^{1}H-NMR, UV-Vis spectroscopy, and elemental analysis. The crystal structures of the complexes were determined by X-ray crystallography. Single-crystal X-ray diffraction analyses revealed that both complexes have distorted octahedral environments, Schiff-base ligand coordinates cobalt in four equatorial positions, and the two axial positions are occupied by pyridines. The pyridines and Schiff-base ligands are involved in N–H···O hydrogen bonds with perchlorate. Biological activities of the ligands and metal complexes have been studied on *Staphylococcus aureus*, *Escherichia coli*, and *Bacillus subtilis* by the well diffusion method. The activity data show the metal complexes to be more potent than the parent ligand against two bacterial species.

Keywords: Cobalt(III) complexes; Crystal structure; Schiff base; Antibacterial activities

1. Introduction

Schiff-base cobalt complexes receive attention for catalysis of oxygenation reactions, oxygen activators, reversible oxygen transport, potent antiviral, antibacterial, antitumor agents, enantioselective, and asymmetric catalysis [1–17]. A characteristic of these complexes is their ability to act as bimolecular models. For example, cobalamines and cobaloximes have been investigated as models for the natural Corrine ring complexes, and thus for vitamin B_{12} and its co-enzyme. The properties of the model complexes are strongly dependent on the nature of the axial and equatorial ligands. Variation of the size and nature of the ligands can be responsible for changes in the

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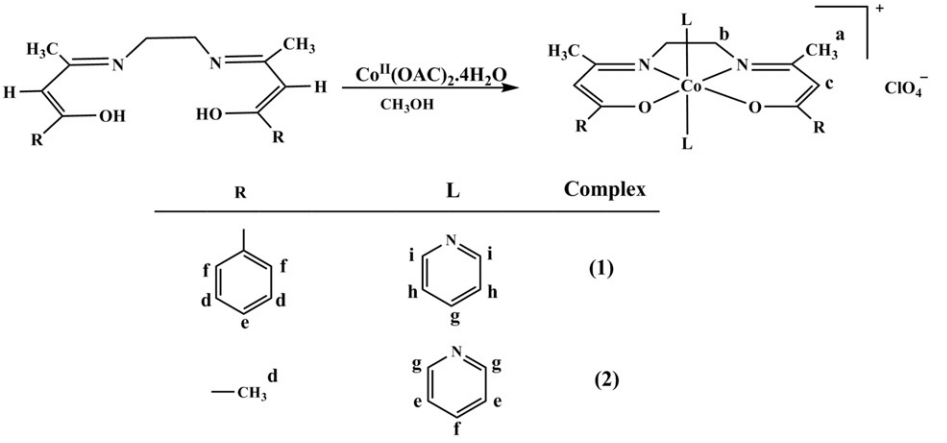
Journal of Coordination Chemistry
ISSN 0095-8972 print/ISSN 1029-0389 online © 2012 Taylor & Francis
http://dx.doi.org/10.1080/00958972.2012.708737



Scheme 1. Reaction pathway for synthesis of the complexes.

coordination geometry. Reactivity, stabilities, and electronic properties of a complex are strongly dependent on these structural changes. In our ongoing studies on the synthesis, structural, spectroscopic, and electrochemical studies of cobalt(III) complexes with Schiff-base ligands [18–20], we report here the syntheses and characterizations of *trans*-[$Co^{III}((BA)_2en)(py)_2]ClO_4$ (**1**) and *trans*-[$Co^{III}(acacen)(py)_2]ClO_4$ (**2**) (scheme 1). Antibacterial activities of the Schiff-base ligands and their complexes against *Bacillus subtilis* (Gram-positive), *Staphylococcus aureus* (Gram-positive), and *Escherichia coli* (Gram-negative) are investigated. Our results show that the cobalt(III) complexes have higher antimicrobial activity than their free Schiff bases.

2. Experimental

2.1. *Reagents and measurements*

All chemicals and solvents were of the highest purity and used as received. All syntheses and purifications were conducted in aerobic condition. The Schiff-base ligands, bis(acetylacetone)ethylenediimine, H_2acacen, and bis(benzoylacetone)ethylenediimine, $H_2(BA)_2$en, and their cobalt(II) complexes were prepared as described in the literature [21]. ^{1}H-NMR spectra were obtained on a BRUKER AVANCE DR X500 (500 MHz) spectrometer. Proton chemical shifts are reported in ppm relative to an internal standard of Me_4Si. IR spectra were obtained as KBr plates using a Bruker FT-IR instrument and UV-Vis spectra were obtained on a Shimadzu UV-1650PC spectrophotometer. Elemental analyses were performed using a Perkin-Elmer 2400II CHNS-O elemental analyzer.

Caution! Perchlorate complexes are potentially explosive [22] especially in the presence of organic ligands. Only a small amount of these materials should be prepared and handled with care.

2.2. *Preparation of the complexes*

2.2.1. Synthesis of $[Co^{III}((BA)_2en)(pyridine)_2]ClO_4$ (1). A solution of $Co^{II}(CH_3COO)_2 \cdot 4H_2O$ (0.125 g, 0.5 mmol) in MeOH (10 mL) was added dropwise to a solution of $H_2(BA)_2en$ (0.174 g, 0.5 mmol) in MeOH (30 mL). The mixture refluxed for 2 h after which it was cooled to room temperature. To the resulting red solution pyridine (4 mmol) was added and air was bubbled through the reaction mixture for about 3 h. The resulting brown solution was filtered and a solution of 0.5 mmol $NaClO_4$ in 5 mL methanol was added to the filtrate and stirred for 5 min. A brown dark microcrystalline solid was produced by slow evaporation of methanol at room temperature. The product was then recrystallized from chloroform–toluene (2 : 1 v/v) and dark red crystals suitable for X-ray crystallography were obtained. The crystals were filtered off and washed with a small amount of cold methanol and dried under vacuum. Yield: 50%. IR (KBr, cm^{-1}): 1504 (C=N), 1095 (Cl–O) UV-Vis: λ_{max} (nm), ε ($L\,mol^{-1}\,cm^{-1}$) (CH_3CN) 370 (12,300), 407 (6420), 439 (1900). ^{1}H-NMR (500 MHz, ($CDCl_3$, δ, ppm): 2.50 (s, $6H_a$), 3.99 (m, $4H_b$), 5.70 (s, $1H_c$), 7.28 (t, $2H_d$), 7.44 (m, $6H_{f,e}$), 7.70 (tt, $2H_g$), 7.95 (dd, $4H_h$), 8.17 (d, $4H_i$). Anal. Calcd for $CoC_{32}H_{32}N_4O_6Cl$ (%): C, 68.20; H, 5.72; N, 9.94. Found (%): C, 68.12; H, 5.55; N, 9.89.

2.2.2. Synthesis of $[Co^{III}(acacen)(pyridine)_2]ClO_4$ (2). To a stirring solution of $Co^{II}(CH_3COO)_2 \cdot 4H_2O$ (0.125 g, 0.5 mmol) in methanol (25 mL) an equimolar amount of H_2acacen (0.112 g, 0.5 mmol) was added. To this solution pyridine (4 mmol) was added and air was bubbled through the reaction mixture for 3 h. To the resulting dark brown solution, a solution of 0.5 mmol of $NaClO_4$ in 5 mL methanol was added and the mixture stirred for 5 min. Dark red crystals of **2** suitable for X-ray crystallography were obtained after 3 days by slow evaporation of the solvent. Yield: 60%. IR (KBr, cm^{-1}): 1512 (C=N), 1088 (Cl–O) UV-Vis: λ_{max} (nm), ε ($L\,mol^{-1}\,cm^{-1}$) (CH_3CN) 341 (8100), 357 (5600), 437 (681). ^{1}H-NMR (500 MHz, ($CDCl_3$, δ, ppm): 2.07 (m, $6H_a$), 2.29 (s, $6H_d$), 3.78 (m, $4H_b$), 4.94 (s, $2H_c$), 7.36 (t, $4H_e$), 7.78 (t, $2H_f$), 8.01(d, $4H_g$). Anal. Calcd for $CoC_{22}H_{28}N_4O_6Cl$ (%): C, 49.04; H, 5.24; N, 10.40. Found (%): C, 48.98; H, 5.11; N, 10.43.

2.3. *X-ray crystallography analyses for 1 and 2*

The X-ray single-crystal data for **1** and **2** were collected at 296(1) K on a STOE IPDS 2 T diffractometer (Mo-Kα = 0.71073 Å). The crystal parameters and refinement data are shown in table 1. Cell parameters were retrieved using X-AREA [23] software and refined using X-AREA on all observed reflections. Data reduction and correction for Lorentz-polarization and decay were performed using X-AREA software. Absorption corrections were applied using MULABS [24] in PLATON [25]. The structures were solved by direct methods and refined by full-matrix least squares on F^2 for all data using SHELXTL [26]. All calculations were performed by PLATON. All non-hydrogen atoms were refined anisotropically. Hydrogen atoms were positioned geometrically and refined with a riding model approximation with their parameters constrained to the parent atom with $U_{iso}(H) = 1.2$ or 1.5 $U_{eq}(C)$.

Table 1. Crystal data, data collection, and structure refinement.

Compound	**1**	**2**
Formula	$C_{32}H_{32}N_4O_6ClCo$	$C_{22}H_{28}N_4O_6ClCo$
Formula weight	663.00	538.86
Crystal system	Triclinic	Monoclinic
Space group	$P\bar{1}$	$P2_1/c$
Unit cell dimensions (Å, °)		
a	11.087(5)	13.6189(13)
b	11.544(5)	15.6823(10)
c	13.966(5)	12.2615(13)
α	77.848(5)	90
β	68.553(5)	110.316(6)
γ	77.594(5)	90
Volume (Å^3), Z	1607.7(12), 2	2455.9(4), 4
Calculated density (g cm^{-3})	1.370	1.457
F(000)	688	1120
Absorption coefficient (mm^{-1})	0.665	0.852
θ range (°)	1.8–26	1.6–29.2
Limiting indices	$-12 \le h \le 13$; $-13 \le k \le 14$; $0 \le l \le 17$	$-18 \le h \le 18$; $-17 \le k \le 21$; $-15 \le l \le 16$
Reflections		
Collected	6194	15123
Unique (R_{int})	6194 (0.056)	6314(0.088)
with $I > 2\sigma(I)$	3614	3468
Number of parameters	391	339
Final R indices [$I > 2\sigma(I)$]	$R_1 = 0.0571$, $wR_2 = 0.1081$	$R_1 = 0.0588$, $wR_2 = 0.1126$
R indices (all data)	$R_1 = 0.1110$, $wR_2 = 0.1211$	$R_1 = 0.1214$, $wR_2 = 0.1303$
Goodness-of-fit on F^2	0.896	0.916
Max/min $\Delta\rho$ (e Å^{-3})	0.60 and −0.45	0.26 and −0.46

2.4. *Biological studies*

2.4.1. Bacterial strains. Metal complexes and ligands were individually tested against microorganisms (Gram-negative and Gram-positive), *B. subtilis* (PTCC No.: 1254; ATCC 12711); *S. aureus* (PTCC No.: 1112; ATCC 6538), and *E. coli* (PTCC No.: 1397; ATCC 15224). The organisms were purchased from the Iranian Research Organization for Science and Technology.

2.4.2. Disc diffusion assay. Single-disc diffusion as a qualitative assay was performed according to Bauer *et al.* [27]. Four to five colonies of each organism were inoculated into 4 mL of broth and incubated for 4–6 h at 37°C. A suspension of each organism was then standardized against a turbidity standard of 0.5 McFarland [28]. Bacteria were cultured on agar plates using sterile absorbent cotton swabs. Then plates were incubated at 37°C and the zones of inhibition were measured after 24 h. Each organism was tested in duplicate on different days to measure the reproducibility of the test. Ampicillin (10 µg per disc) and penicillin (10 µg per disc), purchased from PadtanTeb Company (Iran), were used as reference antibacterial agents. A set of assay tubes containing only inoculated medium was kept as negative control and likewise solvent controls were also done simultaneously. All assays were performed in duplicate.

2.4.3. Minimum inhibitory concentration. Minimum inhibitory concentrations (MICs) were determined by the broth twofold dilution method as a quantitative assay [29]. Serial diluted compounds of 0.01–0.52 mg mL^{-1} were added to inoculums of approximately 1.5×10^6 organisms per mL in log-phase growth. The cultures were incubated on a rotary shaker at 37°C for 24 h. MIC (μg mL^{-1}) of each tested compound was defined as the lowest concentration exhibiting no visible growth compared with the drug-free control wells. Each organism was tested in duplicate on different days to measure the reproducibility of the test.

3. Results and discussion

Six-coordinate mononuclear **1** and **2** are prepared by the direct reaction of the corresponding ligands, $H_2(BA)_2$en and H_2acacen, and $Co^{II}(CH_3COO)_2 \cdot 4H_2O$ in the presence of the pyridine under aerobic conditions. The cobalt(III) complexes of $H_2(BA)_2$en and H_2acacen have high solubility in CH_3Cl and both complexes are soluble in DMF, DMSO, THF, and dioxane. The chemical formulae of the complexes have been confirmed by elemental analyses and X-ray single-crystal structure determination. Diamagnetism of the complexes indicated that cobalt has a low-spin d^6 configuration.

3.1. *Characterization of complexes*

IR spectra of BA_2en and acacen show ν(C−N) at 1540 cm^{-1}, shift to lower frequencies by 28–36 cm^{-1} in the corresponding cobalt complexes, indicating coordination through nitrogen of the azomethine. The stretching vibrations of ClO_4^- are observed at 1095 cm^{-1} in **1** and at 1088 cm^{-1} in **2** [30]. Electronic spectra of the complexes were recorded in acetonitrile at room temperature. The absorption spectrum of $H_2(BA)_2$en shows a band at 350 nm, attributed to π–π* transition of azomethine, and a band at 242 nm due to the π–π* transition of the benzene ring of benzoyl acetone. No n–π* band is observed in the $H_2(BA)_2$en spectrum [31]. The first π–π* transition in *trans*-$[Co^{III}((BA)_2en)(py)_2]ClO_4$ (**1**) is red shifted approximately 20 nm relative to that of the free ligand and appears at 370 nm. The absorption spectrum of H_2acacen shows intense bands with maxima at 305 and 323 nm; the splitting in the system has been attributed to coupling of the two azomethine chromophores. These bands are red shifted by 24–36 nm in the corresponding cobalt complex, presumably due to increased conjugation in the coordinated ligand (appearing at 341 and 357 nm, respectively). The positions of bands indicate that these complexes have distorted octahedral geometry. The ^{1}H-NMR spectra of the complexes in $CDCl_3$ with the chemical shifts, expressed in ppm downfield from tetramethylsilane, are presented in section 2. The octahedral geometry of **1** is evident from the X-ray structural analysis (figure 1). An octahedral *trans*-structure for **2** can be inferred based on the similarity of the ^{1}H-NMR spectra of this complex with that of **1**. The two methyl protons, H_a, adjacent to the iminic nitrogen atoms appear at 2.50 ppm and the four ethylenediamine protons, H_b, have a multiplet at 3.99 ppm. The signal at 5.70 ppm in the ^{1}H-NMR spectrum of **1** is assigned to the two =CH groups, indicating that the equatorial coordination sites are occupied by $(BA)_2$en, leading to magnetically equivalent =CH protons. The aromatic protons of the phenyl

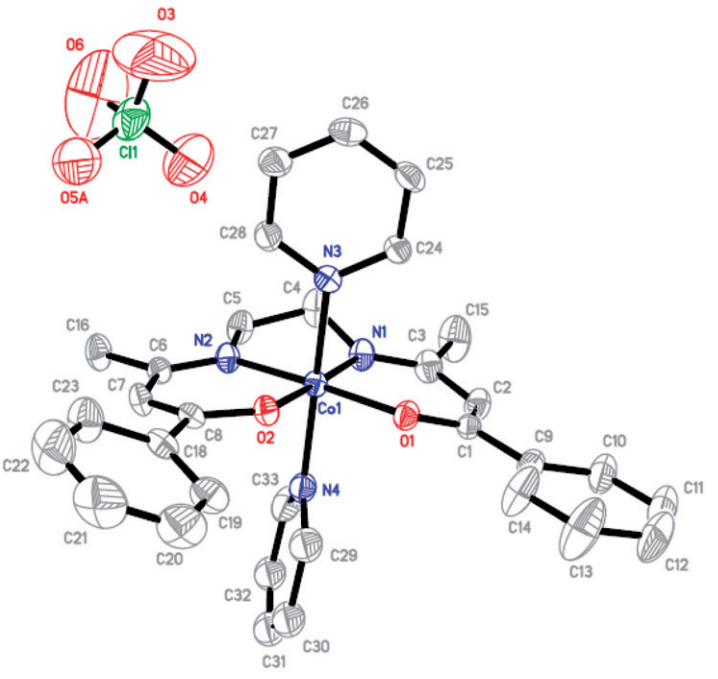


Figure 1. The molecular structure of **1** with labeling scheme. Displacement ellipsoids are drawn at 30% probability level and hydrogen atoms are omitted for clarity. Only the major part of the disordered counter ion is shown.

rings in the Schiff-base ligand are multiplets at 7.28–7.44 ppm (H_d, H_e, H_f). The aromatic protons of the axial pyridine are a triplet of triplets, H_g, at 7.70 ppm, a doublet of triplets, H_h, at 7.95 ppm, and a doublet, H_i, at 8.17 ppm. The ^{1}H-NMR spectra of **2** in $CDCl_3$ show features similar to those observed for **1**, consisting of two signals at 2.07 and 2.29 ppm, assigned to two sets of CH_3 protons, H_a and H_d, respectively. The signal due to protons of the ethylene chelate ring, H_c, is observed as a multiplet at 3.88 ppm. Signals of aromatic protons of the two pyridine rings, H_e, H_f, and H_e are observed as a triplet, triplet, and doublet at 7.36, 7.78, and 8.01 ppm, respectively.

3.2. *Crystal structures of 1 and 2*

The molecular structures of **1** and **2** are shown in figures 1 and 3 and the crystal packings are shown in figures 2 and 4, respectively. Selected bond lengths and angles are listed in table 2. Compounds **1** and **2** are composed of $[Co^{III}((BA)_2en)(py)_2]^+$ and $[Co^{III}(acacen)(py)_2]^+$, respectively, and ClO_4^-. In both compounds, two pyridines occupy axial sites. The dihedral angles formed by the two pyridines are 85.0(2)° for **1** and 89.1(2)° for **2**. In both complexes oxygen atoms of perchlorates were disordered in two positions with the refined site occupancy ratios of 0.62(4)/0.38(4) and 0.574(16)/0.4269(16) in **1** and **2**, respectively. The Schiff-base ligands coordinate to cobalt in four equatorial positions. The coordination geometry is distorted octahedral in both cases, with the *trans* and *cis* angles lying in the ranges 175.02(11)–179.82(11)° and

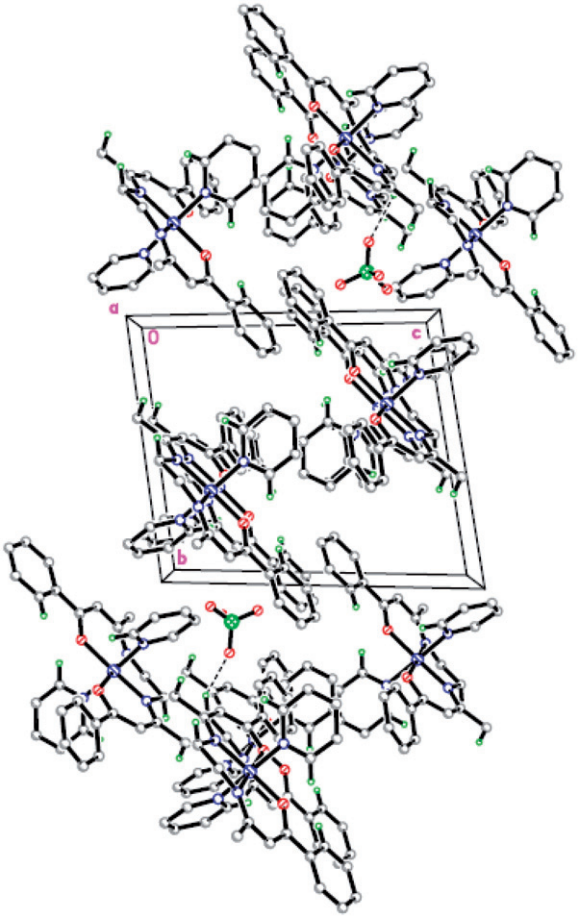


Figure 2. The crystal packing of **1** showing linking of the cations and anions through the intermolecular C–H···O interactions. The dashed lines denote hydrogen bonds.

84.71(12)–95.19(12)°, respectively. Two related structures with amines as axial ligands, *trans*-[Co(acacen)(piperidine)$_2$]NCS [32] and *trans*-[Co((BA)$_2$en)(mrpln)$_2$]ClO$_4$ [31] have been reported and the bond angles around the metal compare well with the values determined for **1** and **2**. For example, all angles around Co deviate significantly from 90° (84.6(1)–95.2(1)° and 85.87(11)–94.26(11)°) in *trans*-[Co(acacen)(piperidine)$_2$]NCS and *trans*-[Co((BA)$_2$en)(mrpln)$_2$]ClO$_4$, respectively. The corresponding Co–O and Co–N distances are quite close. In fact, the Co(1)–N(1), Co(1)–N(2), Co(1)–O(1), and Co(1)–O(2) distances in the equatorial plane in the two molecules are virtually identical, 1.895(4), 1.891(3), 1.899(3), and 1.901(3) Å, respectively, in **1** and 1.896(3), 1.898(3), 1.891(2), and 1.909(2) Å in **2**. The distances between cobalt and the two axial nitrogen atoms differ only slightly (1.967(3) and 1.973(4) Å in **1** and 1.962(3) and 1.972(3) Å in **2**) and compare well with Co–N distances in related complexes *trans*-[Co((BA)$_2$en)(mrpln)$_2$]ClO$_4$ (2.042(3), 2.038(3) Å) [31]. The Co–N$_{eq}$ are shorter than Co–N$_{ax}$ by approximately 0.072–0.082 Å due to the presence of π-backbonding in Co–N$_{imine}$ of the equatorial ligand. Those differences are 0.135–0.145 Å and 0.133–0.149 Å

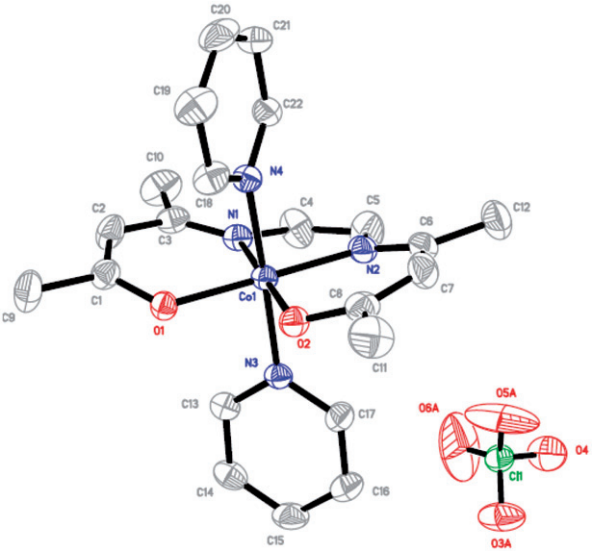


Figure 3. The molecular structure of **2** with atom-labeling scheme. Displacement ellipsoids are drawn at 30% probability level and hydrogen atoms are omitted for clarity. Only the major part of the disordered counter ion is shown.

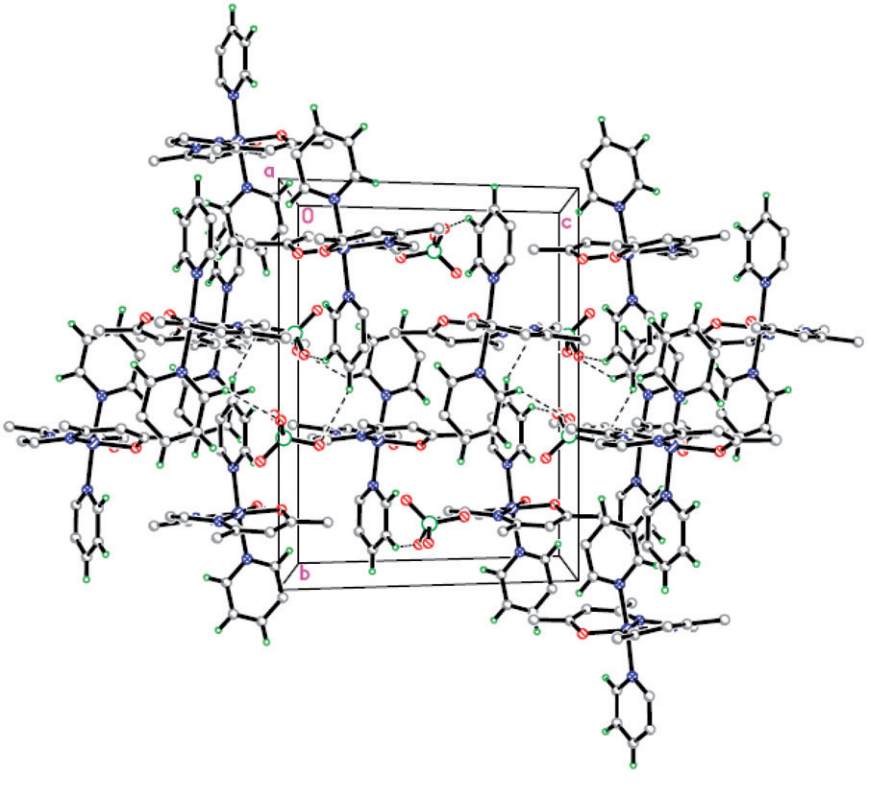


Figure 4. The crystal packing of **2** showing the linking of molecules through intermolecular hydrogen bonds. The dashed lines denote hydrogen bonds.

Table 2. Selected geometrical parameters.

1		**2**	
Co1–N1	1.895(4)	Co1–N1	1.896(3)
Co1–N2	1.891(3)	Co1–N2	1.898(3)
Co1–O1	1.899(3)	Co1–O1	1.891(2)
Co1–O2	1.901(3)	Co1–O2	1.909(2)
Co1–N3	1.967(3)	Co1–N3	1.962(3)
Co1–N4	1.973(4)	Co1–N4	1.972(3)
O1–Co1–O2	84.86(11)	O1–Co1–O2	85.37(10)
O1–Co1–N1	94.72(13)	O1–Co1–N1	94.74(10)
O1–Co1–N3	90.36(11)	O1–Co1–N3	89.03(10)
O1–Co1–N4	88.01(13)	O1–Co1–N4	87.93(10)
O2–Co1–N2	94.75(13)	O2–Co1–N2	95.19(12)
O2–Co1–N3	87.46(12)	O2–Co1–N3	87.91(11)
O2–Co1–N4	89.09(15)	O2–Co1–N4	87.91(10)
N1–Co1–N2	85.79(15)	N1–Co1–N2	84.71(12)
N1–Co1–N3	89.64(15)	N1–Co1–N3	91.95(12)
N1–Co1–N4	93.79(18)	N1–Co1–N4	92.24(11)
N2–Co1–N3	91.92(12)	N2–Co1–N3	91.28(11)
N2–Co1–N4	89.69(14)	N2–Co1–N4	91.80(11)
N3–Co1–N4	176.31(17)	O2–Co1–N1	179.82(11)
O1–Co1–N2	177.67(13)	N3–Co1–N4	175.02(11)
O2–Co1–N1	177.07(14)	O1–Co1–N2	179.37(11)

Table 3. Hydrogen bonds for **1**.

D–H···A	*d*(D–H) (Å)	*d*(H···A) (Å)	*d*(D···A) (Å)	∠(DHA) (°)
C5–H5A···O4	0.97	2.4	3.264(8)	149
C14–H14A···O1	0.93	2.36	2.698(6)	101
C16–H16B···O5A	0.96	2.59	3.51(3)	162
C24–H24A···O1	0.93	2.48	2.879(5)	106
C28–H28A···N2	0.93	2.53	2.978(5)	110
C29–H29A···O1	0.93	2.57	2.940(7)	104
C29–H29A···O2	0.93	2.39	2.804(6)	107

in *trans*-[Co((BA)$_2$en)(mrpln)$_2$]ClO$_4$ and *trans*-[Co((BA)$_2$en)(mrpln)$_2$]ClO$_4$, respectively. Compounds **1** and **2** are packed in undulating layers parallel to the (100) planes of their monoclinic unit cells. The pyridine molecules and Schiff bases are involved in N–H···O hydrogen bonds with perchlorate (tables 3 and 4).

3.3. *Antibacterial properties*

Table 5 shows the antibacterial activities of both Schiff bases and corresponding complexes as well as ampicillin and penicillin as standards, evaluated by the disc diffusion method and serial dilution sensitivity test against both Gram-positive and Gram-negative bacteria. According to the Clinical and Laboratory Standards Institute interpretive criteria [33], **1** and **2** show high activity against Gram-negative and Gram-positive bacteria. Compounds **1** and **2** were most effective against *S. aureus* with zones of inhibition of 30 and 17 mm, *B. subtilis* with zones of inhibition 24 and 15 mm, and

Table 4. Hydrogen bonds for **2**.

D–H···A	*d*(D–H) (Å)	*d*(H···A) (Å)	*d*(D···A) (Å)	∠(DHA) (°)
C13–H13A···O1	0.93	2.6	2.913(4)	100
C13–H13A···O6A^{i}	0.93	2.46	3.103(17)	126
C14–H14A···O6A^{i}	0.93	2.58	3.154(17)	120
C15–H15A···O4^{ii}	0.93	2.57	3.403(7)	149
C18–H18A···O1	0.93	2.5	2.861(4)	103
C18–H18A···O2	0.93	2.43	2.827(4)	106
C20–H20A···O3A^{ii}	0.93	2.54	3.287(12)	138
C21–H21A···O3A^{iii}	0.93	2.51	3.350(14)	150
C22–H22A···O5A^{iii}	0.93	2.41	3.23(2)	147

Symmetry codes: $^{i}1-x, 1-y, 1-z$; $^{ii}x, y, -1+z$; $^{iii}x, 1/2-y, -1/2+z$.

Table 5. Zone of inhibition of antibacterial compound against pathogenic bacteria (mm).

Compound	*S. aureus*	*E. coli*	*B. subtilis*
H_2acacen	–	–	–
$H_2(BA)_2$en	–	–	–
trans-[Co^{III}(acacen)$(py)_2$]ClO_4 (**2**)	17	11	15
trans-[Co^{III}($(BA)_2$en)$(py)_2$]ClO_4 (**1**)	30	25	24
Penicillin (10 μg per disc)	15	10	10
Ampicillin (10 μg per disc)	25	14	18

Table 6. MIC of synthesized compounds against growth of bacteria (μg mL^{-1}).

Compound	*S. aureus*	*E. coli*	*B. subtilis*
H_2acacen	–	–	–
$H_2(BA)_2$en	–	–	–
trans-[Co^{III}(acacen)$(py)_2$]ClO_4 (**2**)	45	52.5	24
trans-[Co^{III}($(BA)_2$en)$(py)_2$]ClO_4 (**1**)	10	25.5	11
Penicillin	6.4	80	4

MIC: minimal inhibitory concentration.

E. coli with zones of inhibition 25 and 11 mm, respectively. However, Schiff bases did not show activity against Gram-positive or Gram-negative bacteria (table 5). Enhanced activity of the metal complexes may arise from coordination; Co(OAc) has low inhibitory properties [34]. Potent antibacterial activity of cobalt(II) and cobalt(III) Schiff-base complexes have been reported [34, 35]. Complexes **1** and **2** show rather good antibacterial behavior compared to other salicylaldehyde and diamine derived complexes [36–38]. In the disc diffusion method, the diameter of the zone is related to the susceptibility of the isolate and to the diffusion rate of the drug through the agar medium [39]. MIC values of the three bacterial strains used in this study are presented in table 6. Complex **1** containing an electron-withdrawing group showed a wide range of bactericidal activities against Gram-positive and Gram-negative bacteria, more potent than, or similar with, penicillin. The increased activity of the metal chelates can be explained by Overtone's concept [40] and Tweedy's theory [41]. Antibacterial activity of

chemical compounds influence DNA structure, interfere with replication, transcription, translation, and other biological systems.

4. Conclusion

Co(III) complexes of BA_2en and acacen have been prepared. Structural data show six-coordinate distorted octahedral for cobalt(III) complexes with tetradentate Schiff-base ligands. The Co(III) complexes show rather good antibacterial behavior compared to other salicylaldehyde and diamine complexes. The antibacterial (MIC) results showed that the Co(III) complexes were more active than the Schiff bases, arising from coordination.

Supplementary material

Full details of data collections and structure determinations have been deposited with the Cambridge Crystallographic Data Centre, CCDC 815383 and 815384. These data can be obtained free of charge *via* http://www.ccdc.cam.ac.uk/conts/retrieving.html, or from the Cambridge Crystallographic Data Centre, 12 Union Road, Cambridge CB2 1EZ, UK; Fax: (+44) 1223-336-033; or E-mail: deposit@ccdc.cam.ac.uk

Acknowledgments

MS thanks Semnan University for supporting this study. The authors are grateful to Dr. Arezou Rezaei and Dr. Mahbod Morshedi for their helpful comments.

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