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## Research Article

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## Abstract

A new cobalt(II) coordination polymer,  $(\{H_3N-(CH_2)_4-NH_3\}[Co(OOC-C_6H_4-COO)_2])_n$  (**1**), has been synthesized by a conventional solution-based method using an amine-templating approach. The compound was characterized by elemental analysis, FT-IR and UV-Vis spectroscopy, thermogravimetric analysis (TGA), powder X-ray diffraction (PXRD), and single-crystal X-ray diffraction. Crystallographic studies reveal that the doubly deprotonated 1,2-benzenedicarboxylate (1,2-BDC) ligands bridge adjacent Co(II) centers through their carboxylate groups, generating repeated 14-membered cyclic units that extend into a one-dimensional anionic helical chain. Charge balance is maintained by protonated 1,4-diaminobutane cations located between the polymeric chains. Extensive N $\cdots$ H $\cdots$ O hydrogen-bonding interactions between the organic cations and the carboxylate oxygen atoms further consolidate the crystal packing into a robust three-dimensional supramolecular architecture. The thermal stability and phase purity of the compound were confirmed by TGA and PXRD analyses, respectively. In addition, antimicrobial investigations demonstrated that the coordination polymer exhibits promising activity against selected microbial strains. The present study highlights the effectiveness of amine-templating strategies in the construction of structurally intriguing cobalt(II)-based coordination polymers with potential biological applications.

Keywords: Coordination polymer; anionic coordination framework; soft solution route; crystal

Structure; antimicrobial studies

## Introduction

Coordination polymers (CPs) have received considerable attention during the past few decades owing to their fascinating structural diversity and potential applications in areas such as gas storage and separation, catalysis, magnetism, luminescence, sensing, and ion exchange [1–6]. The design and synthesis of CPs largely depend on the judicious selection of metal centres and organic ligands. In this regard, transition metal ions are particularly attractive because of their variable oxidation states, diverse coordination geometries, and rich electronic properties, which facilitate the formation of architectures with varied dimensionalities and functionalities [7,8]. Among the numerous ligands employed in the construction of CPs, polycarboxylate ligands have proven to be especially versatile due to their ability to exhibit a variety of coordination modes, including monodentate, chelating, and bridging fashions. Such flexibility enables the generation of one-, two-, and three-dimensional polymeric frameworks with diverse topologies [9–11]. Furthermore, the strong metal–oxygen interactions associated with carboxylate ligands often contribute to enhanced structural stability and robustness of the resulting frameworks. In addition to their physicochemical properties, transition metal carboxylate systems have attracted increasing interest because of their biological activities. Several studies have demonstrated that metal-based coordination compounds exhibit significant antibacterial and antifungal activities, arising from synergistic effects between the metal centers and the coordinating ligands [12,13]. Consequently, the development of new transition metal carboxylate coordination polymers with potential biological activity remains an active area of research. Despite significant advances in crystal engineering, the rational synthesis of coordination polymers continues to be challenging because subtle variations in synthetic parameters, including solvent composition, pH, temperature, and templating agents, can markedly influence framework assembly [14,15]. In particular, amines have frequently been employed as structure-directing agents for the generation of novel coordination architectures.

As part of our ongoing investigations on transition metal carboxylate coordination polymers, several synthetic approaches were explored; however, the desired framework was obtained only under amine-templated conditions. Herein, we report the synthesis and crystal structure of a new cobalt(II) carboxylate coordination polymer,  $(\{H_3N-(CH_2)_4-NH_3\}[Co(OOC-C_6H_4-COO)_2])_n$ , (**1**) which was characterized by single-crystal X-ray diffraction analysis. In addition, its antibacterial activity against *Escherichia coli* and *Bacillus subtilis* and antifungal activity against *Candida albicans* were evaluated to assess its potential

biological properties.

## Experimental

### Materials and physical methods

All commercially available chemicals were of analytical grade and used without further purification. The Co(II) bis-phthalate based anionic polymeric system was synthesised using an amine templated technique. Stoichiometric amounts of metal acetate, an aliphatic flexible diamine, and 1,2-benzene dicarboxylic acid or phthalic acid, (1,2-H<sub>2</sub>BDC) were thoroughly mixed under constant stirring in a methanol-water medium. The resulting metal complex formed in solution, which was filtered, and left undisturbed at room temperature for crystallization. Good quality crystals separated after three days were collected, washed, and dried in air. Elemental analyses (C, H, N and S) were performed using a Vario III elemental analyser. FT-IR spectra were recorded using a Shimadzu IR-470 spectrophotometer operating in the range 4000-400cm<sup>-1</sup> using samples in the form of KBr pellets. Electronic spectra were obtained with Shimadzu UV-160A spectrophotometer operating in the range of 200-1100nm. Thermogravimetric analysis (TGA) was carried out on a Shimadzu DTG-60 thermal analyser under a nitrogen atmosphere at a heating rate of 10°Cmin<sup>-1</sup>. Powder X ray diffraction was recorded on a Bruker D8 Advance diffractometer using Cu K $\alpha$  radiation ( $\lambda$  = 1.5406 Å). Single crystal X-ray diffraction data were collected on a Bruker APEX2 diffractometer using MoK $\alpha$ 1 radiation with a wavelength of  $\lambda$  = 0.71073 Å.

### Synthesis of $\{(\text{H}_3\text{N}-(\text{CH}_2)_4-\text{NH}_3)[\text{Co}(\text{OOC}-\text{C}_6\text{H}_4-\text{COO})_2]\}_n$ (**1**)

It was prepared by mixing warm aqueous solution (15 mL water) of cobalt acetate (2.49 g, 10 mmol) with 1,4-diaminobutane (1 mL, 10 mmol), followed by the addition of two equivalents of phthalic acid (3.32 g, 20 mmol) as a solution in 1:1 methanol-water mixture (20 mL). Dark bluish needle type crystals get formed after three days. (Yield: 72%). Anal. Calc. (%) for C<sub>20</sub>H<sub>22</sub>CoN<sub>2</sub>O<sub>8</sub>: C, 50.31; H,4.61; N, 5.86. Found (%): C, 50.08; H,4.89; N, 5.83. IR data (KBr, cm<sup>-1</sup>): 3100 m, 3030 w, 2910 m, 2839 m, 1625 w, 1594 s, 1287 s, 1030 s, 950 m, 809 s, 780 s, 613 s, 450 s, 430 w.

### X-ray Crystallography

Single crystals of complex (**1**) were grown by slow evaporation of the solution. Dark blue needle type crystal of approximate size 0.30 x 0.03 x 0.02 mm, was used for data collection on Bruker SMART APEX CCD diffractometer using Mo K $\alpha$  radiation ( $\lambda$ = 0.71073 Å) with fine focus tube with 50kV and 30mA. All the data were corrected for Lorentzian, polarisation and absorption effects. SHELX-97 [16-18]

was used for structure solution and full matrix least squares refinement on  $F^2$ . Hydrogen atoms were included in the refinement as per the riding model.

### **Antimicrobial activity**

In order to access the biological significance and ability of the sample, the antibacterial and antifungal activities were determined by Agar well diffusion method [19,20]. The antimicrobials present in the samples are allowed to diffuse out into the medium and interact in a plate freshly seeded with the test organisms. The resulting zones of inhibition will be uniformly circular as there will be a confluent lawn of growth. The diameter of zone of inhibition can be measured in millimeters.

#### **(a), Antibacterial Activity**

Petriplates containing 20ml Muller Hinton Agar Medium (The medium was prepared by dissolving 33.8 g of the commercially available Muller Hinton Agar Medium (MHI Agar Media) in 1000ml of distilled water. The dissolved medium was autoclaved at 15 lbs pressure at 121°C for 15 minutes. The autoclaved medium was mixed well and poured onto 100mm petriplates (25-30ml/plate) while still molten.) were seeded with bacterial culture of *E.coli* and *Bacillus subtilis* (growth of culture adjusted according to McFarland Standard, 0.5%). Wells of approximately 10mm was bored using a well cutter and different concentrations of sample such as 250µg, 500µg and 1000µg were added. The plates were then incubated at 37°C for 24 hours. The antibacterial activity was assayed by measuring the diameter of the inhibition zone formed around the well (NCCLS, 1993). Streptomycin was used as a positive control.

#### **(b), Antifungal Activity**

Potato Dextrose agar plates were prepared and overnight grown species of fungus, *Candida albicans* were swabbed. Wells of approximately 10mm was bored using a well cutter and samples of different concentrations such as 250µg, 500µg and 1000µg were added. The zone of inhibition was measured after overnight incubation at room temperature and compared with that of standard antimycotic (Clotrimazole) (NCCLS, 1993).

## **Results and discussion**

### **Synthesis of complexes and spectroscopy**

The soft solution assembly of complex (**1**) from metal ion nodes and benzene 1,2-dicarboxylate linkers guided by an amine template yielded a water-soluble coordination framework with remarkable antibacterial and antifungal activity. The reactions were conducted at room temperature using a 1:1 mixture of methanol and water. Crystals suitable for X-ray diffraction were grown by slow evaporation at room temperature.

The product was isolated as dark bluish, air-stable microcrystalline solid and was further characterized by elemental analysis, single crystal X-ray diffraction, TGA, IR and UV-vis spectroscopy. The most striking features of the IR spectrum is the characteristic asymmetric and symmetric stretching vibrations of the carboxylate groups,  $\nu_{as}(\text{COO}^-)$  and  $\nu_s(\text{COO}^-)$ , observed at 1594 and 1379  $\text{cm}^{-1}$ , respectively. The corresponding energy separation ( $\Delta\nu = 215 \text{ cm}^{-1}$ ) clearly indicates that the carboxylate groups coordinate exclusively in a monodentate ( $\eta^1$ ) fashion, with no evidence for chelating or bridging coordination modes. Furthermore, the absence of any intense bands above 1650  $\text{cm}^{-1}$  confirms that all carboxylate groups derived from benzene-1,2-dicarboxylic acid are fully deprotonated [Fig. S1]. Elemental (CHN) and single crystal XRD analyses supports the presence of diammonium units associated with  $\text{Co}^{2+}$  ions, conclusively confirming the incorporation of ammonium cations in the structure. This observation is further corroborated by the IR data, wherein no  $\nu(\text{NH}_2)$  stretching bands are detected in the 3200–3400  $\text{cm}^{-1}$  region. Instead, characteristic  $\nu(\text{NH}_3^+)$  stretching vibrations appear in the 3100–3030  $\text{cm}^{-1}$  range. Similarly, the absence of  $\text{NH}_2$ -specific bending modes [ $\delta(\text{NH}_2)$ ] typically observed between 1650 and 1550  $\text{cm}^{-1}$ , along with the appearance of  $\delta(\text{NH}_3^+)$  bending vibrations near 1600  $\text{cm}^{-1}$ , confirms that the amine groups exist in their protonated form. Aliphatic and aromatic  $\nu(\text{C-H})$  stretching vibrations are observed in the 2850–2980  $\text{cm}^{-1}$  region [21,22].

The UV-visible spectrum of complex (**1**) exhibits a strong absorption band at 515 nm (19400  $\text{cm}^{-1}$ ) ( $^4\text{A}_2(\text{F}) \rightarrow ^4\text{T}_1(\text{P})\{\nu_3\}$ ). For tetrahedrally coordinated Co(II) complexes, three spin-allowed electronic transitions are expected:  $^4\text{A}_2(\text{F}) \rightarrow ^4\text{T}_2(\text{F})(\nu_1)$ ,  $^4\text{A}_2(\text{F}) \rightarrow ^4\text{T}_1(\text{F})(\nu_2)$  and  $^4\text{A}_2(\text{F}) \rightarrow ^4\text{T}_1(\text{P})(\nu_3)$  which typically occur at approximately 3300-5000  $\text{cm}^{-1}$ , 5800-9000  $\text{cm}^{-1}$ , and 15000-19000  $\text{cm}^{-1}$ , respectively. Owing to instrumental limitations, the  $\nu_1$  and  $\nu_2$  transitions in the near-IR region could not be monitored; however, the  $\nu_3$  transition was clearly observed in the 17000–19800  $\text{cm}^{-1}$  region. This absorption is characteristic of tetrahedral  $[\text{Co}(\text{OOC-})_4]^{2-}$  nodes and exhibits fine structure attributable to spin-orbit coupling [23,24].

Since the coordination polymer is water soluble, its spectral features were also investigated in solution. While the solid-state spectrum is consistent with tetrahedral ( $T_d$ ) geometry around Co(II), the aqueous solution spectrum displays distinct features indicative of a symmetry change to octahedral ( $O_h$ ), most likely arising from coordination expansion from four to six through  $\text{H}_2\text{O}$  coordination. Interestingly, recrystallization from aqueous solution consistently regenerates the original solid-state compound, in which all Co(II) centres retain tetrahedral coordination. In contrast, solution-state spectra recorded in DMF closely resemble the solid-state spectra, suggesting the absence of coordination expansion in this solvent. These

observations highlight the facile, solvent-induced structural tunability of complex (**1**), specifically mediated by water [Fig. S2].

The room-temperature magnetic moment of complex (**1**) was found to be 4.37 BM, consistent with the presence of three unpaired electrons and confirming tetrahedral coordination around the Co(II) centers.

### Crystal structure of $\{[\text{Co}(\text{OOC}-\text{C}_6\text{H}_4-\text{COO})_2][\text{H}_3\text{N}-(\text{CH}_2)_4-\text{NH}_3]\}_n$ , **1**

The crystal structure of complex (**1**) was established by single-crystal X-ray diffraction analysis. It crystallizes in the monoclinic crystal system with the space group  $C2/c$ . The crystallographic refinement parameters are summarized in Table 1, and selected bond lengths and bond angles are listed in Table 2. A perspective view of the molecular structure with the atom-numbering scheme is shown in Fig. 1.

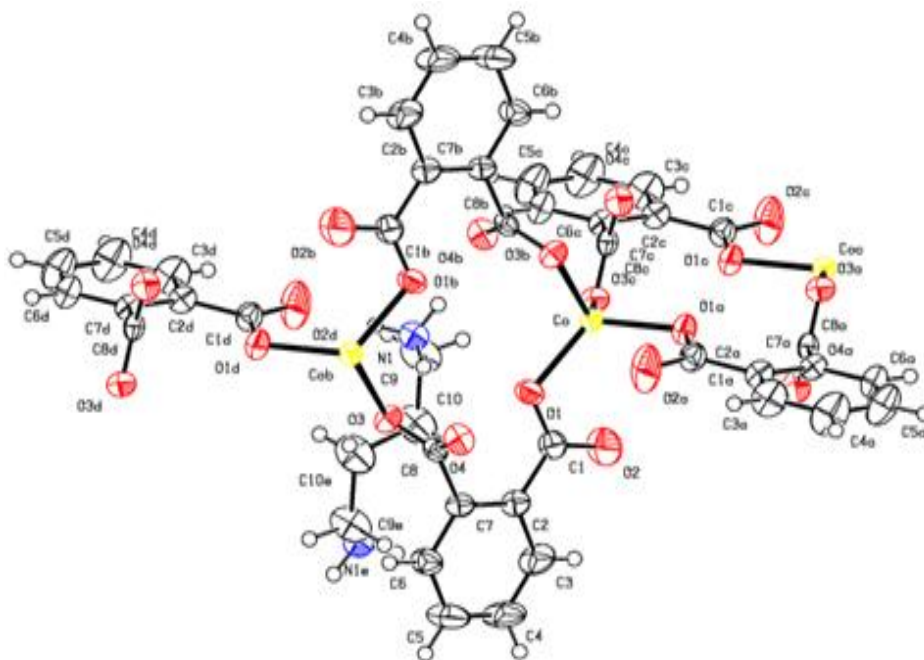


**Fig. 1** ORTEP diagram of complex (**1**), Ellipsoids are drawn at 50% probability

In complex (**1**), each Co(II) center adopts a tetrahedral coordination geometry, being coordinated by four oxygen atoms from deprotonated carboxylate groups belonging to four distinct 1,2-BDC (phthalate) ligands. Each carboxylate group binds to the metal center in a monodentate  $\eta^1$  coordination mode. The resulting  $\text{CoO}_4^{2-}$  units exhibit slight distortions from ideal tetrahedral geometry, as evidenced by O–Co–O bond angles ranging from  $103.13^\circ$  to  $120.54^\circ$ . The Co–O bond lengths fall within a narrow range of 2.001–2.004 Å. Within each phthalate ligands, one of the two  $-\text{COO}^-$  group is coplanar with the aromatic ring, while the second  $-\text{COO}^-$  group is oriented nearly perpendicular to the ring plane. All Co(II) ions in the structure are crystallographically equivalent, as evidenced by the identical Co $\cdots$ Co separation

of 5.522 Å along the one-dimensional chain. In contrast, the Co $\cdots$ Co distances between adjacent chains alternate between 11.011 and 11.394 Å. This variation arises from the tetrahedral coordination environment around the Co(II) centers and the mutually perpendicular arrangement of the phthalate rings, which influences the spatial arrangement of the neighbouring chains. Each 1,2-BDC ligand acts as a  $\mu_2$ -bridging linker, resulting in the formation of a 14-membered cyclic unit composed of two Co(II) ions and two 1,2-BDC ligands. These cyclic units further propagate into a one-dimensional helical chain, as depicted in Fig. 2.

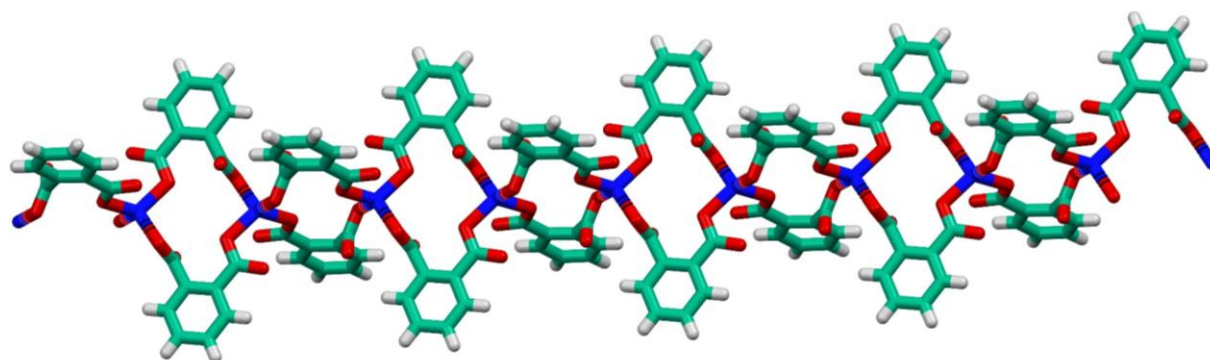


**Fig.2** One-dimensional chain of complex (1) propagating along crystallographic c axis

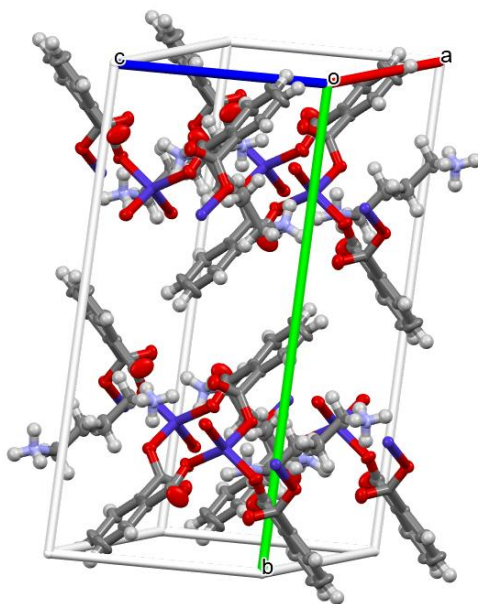


**Fig.3** Crystal packing in complex (1)

The cyclic units are interconnected through Co(II) ions acting as nodes; however, owing to the tetrahedral geometry around the metal centers, successive rings are oriented almost perpendicular to each other. Consequently, the interconnected rings generate an infinite one-dimensional anionic helical chain

consisting of repeated  $\{[\text{Co}(\text{OOC}-\text{C}_6\text{H}_4-\text{COO})_2]^{2-}\}$  units, each carrying a net charge of  $-2$ . Charge neutrality is achieved through the incorporation of 1,4-butyldiammonium di cations ( $^+\text{H}_3\text{N}-(\text{CH}_2)_4-\text{NH}_3^+$ ), which are located between neighbouring anionic chains.

**Table 1** Crystallographic data and refinement details of complex (**1**)

| <b>(1)</b>                                        |                                                               |
|---------------------------------------------------|---------------------------------------------------------------|
| Empirical formula                                 | $\text{C}_{20} \text{H}_{22} \text{Co} \text{N}_2 \text{O}_8$ |
| Formula weight                                    | 477.33                                                        |
| Crystal colour, habit                             | dark blue, needle                                             |
| Crystal size, mm                                  | $0.30 \times 0.03 \times 0.02$                                |
| Temperature (K)                                   | 273K                                                          |
| Crystal system                                    | Monoclinic                                                    |
| Space group                                       | $C2/c$                                                        |
| <i>Unit cell dimensions</i>                       |                                                               |
| $a, \text{\AA}$                                   | 13.924(1)                                                     |
| $b, \text{\AA}$                                   | 20.399(2)                                                     |
| $c, \text{\AA}$                                   | 9.2650(9)                                                     |
| $\alpha, ^\circ$                                  | 90                                                            |
| $\beta, ^\circ$                                   | 127.746(1)                                                    |
| $\gamma, ^\circ$                                  | 90                                                            |
| $V (\text{\AA}^3)$                                | 2080.9(3)                                                     |
| $Z$                                               | 4                                                             |
| $\rho_{\text{calcd}}, \text{gcm}^{-3}$            | 1.524                                                         |
| $\mu (\text{mm}^{-1})$                            | 0.875                                                         |
| $\theta$ Range collected, deg                     | 2.00 - 25.00                                                  |
| $T_{\text{min}}$ and $T_{\text{max}}$             | 0.7817 and 0.9827                                             |
| Reflections collected/unique                      | 5152/1829                                                     |
| Observed reflections [ $I > 2\sigma(I)$ ]         | 1611                                                          |
| Data/restraints/parameters                        | 1829/0/141                                                    |
| GOOF on $F^2$                                     | 1.154                                                         |
| $R_{\text{all}}, R_{\text{obs}}$                  | 0.0739, 0.0652                                                |
| $wR_{2_{\text{all}}}, wR_{2_{\text{obs}}}$        | 0.1674, 0.1612                                                |
| $\Delta\rho_{\text{min,max}} (e \text{\AA}^{-3})$ | -0.784/ 0.955                                                 |

Strong Coulombic interactions between the protonated amine groups and the adjacent anionic coordination polymer chains,  $([\text{Co}(\text{OOC}-\text{C}_6\text{H}_4-\text{COO})_2]^{2-})_n$ , enhance the dimensionality of the system to form a two-dimensional polymeric architecture. Furthermore, in the crystal lattice, each  $^+\text{H}_3\text{N}-(\text{CH}_2)_4-\text{NH}_3^+$  di cation is oriented such that both terminal  $-\text{NH}_3^+$  groups participate in strong  $\text{N}-\text{H}\cdots\text{O}$  hydrogen bonding interactions with coordinated carboxylate oxygen atoms, and  $\pi$ - $\pi$  stacking interactions, ultimately giving rise to a supramolecular multidimensional network.

The experimental PXRD pattern closely matches the simulated pattern generated from the single-crystal X-ray diffraction data, confirming the high phase purity of the bulk sample (Fig. S3 in the supporting information).

**Table 2** Selected bond lengths (Å) and bond angles (°) of complex (1)

|                     |            |                   |            |
|---------------------|------------|-------------------|------------|
| Co-O(1)             | 2.002(3)   | Co-O(1)           | 2.002(3)   |
| Co-O(3)             | 2.004(3)   | Co-O(3)           | 2.004(3)   |
| O(1)-C(1)           | 1.281(5)   | O(2)-C(1)         | 1.249(6)   |
| O(3)-C(8)           | 1.271(5)   | O(3)-Co           | 2.004(3)   |
| O(4)-C(8)           | 1.238(5)   | C(3)-H(3)         | 0.9300     |
| C(4)-H(4)           | 0.9300     | C(5)-H(5)         | 0.9300     |
| C(6)-H(6)           | 0.9300     | C(9)-N(1)         | 1.488(5)   |
| C(9)-H(9)A          | 0.9700     | C(9)H(9)B         | 0.9700     |
| C(10)-H(10)A        | 0.9700     | C(10)-H(10)B      | 0.9700     |
| N(1)-H(1)A          | 0.8433     | N(1)-H(1)B        | 0.8574     |
| N(1)-H(1)C          | 0.8420     |                   |            |
| O(1)-Co-O(1)        | 120.54(18) | O(1)-Co-O(3)      | 103.13(13) |
| O(1)-Co-O(3)        | 106.80(13) | O(1)-Co-O(3)      | 106.80(13) |
| O(1)-Co-O(3)        | 103.13(13) | O(3)-Co-O(3)      | 117.28(16) |
| C(1)-O(1)-Co        | 113.3(3)   | C(8)-O(3)-Co      | 113.9(3)   |
| O(2)-C(1)-O(1)      | 121.5(4)   | O(2)-C(1)-C(2)    | 120.0(4)   |
| O(1)-C(1)-C(2)      | 118.5(4)   | C(4)-C(3)-H(3)    | 119.5      |
| C(2)-C(3)-H(3)      | 119.5      | C(3)-C(4)-H(4)    | 119.8      |
| C(5)-C(4)-H(4)      | 119.8      | C(4)-C(5)-H(5)    | 120.3      |
| C(6)-C(5)-H(5)      | 120.3      | C(5)-C(6)-H(6)    | 119.5      |
| C(7)-C(6)-H(6)      | 119.5      | O(4)-C(8)-O(3)    | 125.0(4)   |
| O(4)-C(8)-C(7)      | 118.3(4)   | O(3)-C(8)-C(7)    | 116.5(4)   |
| N(1)-C(9)-C(10)     | 112.9(4)   | N(1)-C(9)-H(9)A   | 109.0      |
| C(10)-C(9)-H(9)A    | 109.0      | N(1)-C(9)-H(9)B   | 109.0      |
| C(10)-C(9)-H(9)B    | 109.0      | H(9)A-C(9)H(9)B   | 107.8      |
| C(10)-C(10)-H(10)A  | 108.5      | C(9)-C(10)-H(10)A | 108.5      |
| C(10)-C(10)-H(10)B  | 108.5      | C(9)-C(10)-H(10)B | 108.5      |
| H(10)A-C(10)-H(10)B | 107.5      | C(9)-N(1)-H(1)A   | 109.5      |
| C(9)-N(1)-H(1)B     | 112.5      | H(1)A-N(1)-H(1)B  | 108.1      |
| C(9)-N(1)-H(1)C     | 109.2      | H(1)A-N(1)-H(1)C  | 109.1      |
| H(1)B-N(1)-H(1)C    | 108.4      |                   |            |

Symmetry transformations used to generate equivalent atoms: #1 -x,y,-z-1/2 #2 -x+1/2,-y+1/2,-z #3 x-1/2,-y+1/2,z-1/2 #4 -x+1/2,-y+1/2,-z+1

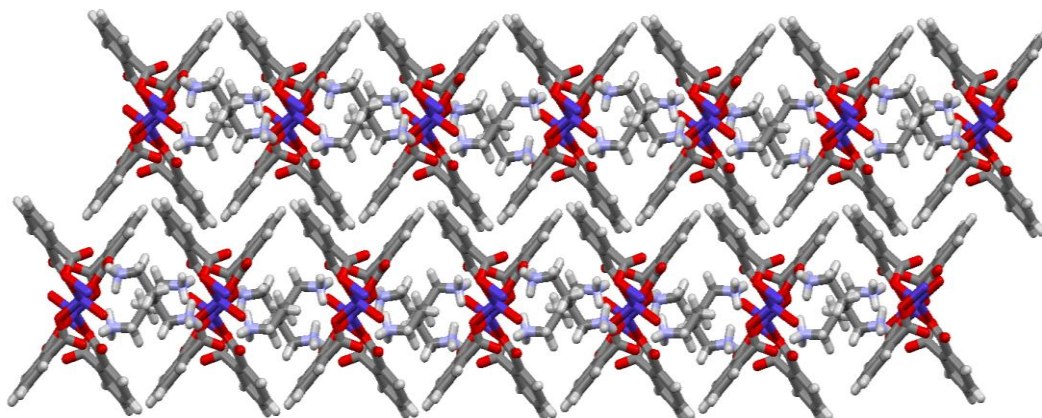


**Fig.4** Packing diagram of complex (1) showing the layered arrangement of two-dimensional  $\{[H_3N-(CH_2)_4-NH_3][Co(OOC-C_6H_4-COO)_2]\}_n$ , viewed along  $a^*$  axis

### Thermogravimetric analysis

As shown in Figure S4, complex (**1**) remains thermally stable up to 281 °C and subsequently undergoes a single-step decomposition process in the temperature range 281–441 °C. This decomposition stage is attributed to the elimination of the organic moieties, with an experimentally observed weight loss of 84.95%, which is in good agreement with the calculated value of 84.31%. The decomposition ultimately affords CoO as the final residue, with an observed residual mass of 15.41% compared to the theoretical value of 15.07%.

### Antibacterial and Antifungal activity of complex (**1**)

Complex (**1**) was screened for antibacterial activities against a Gram-positive bacterial strain (*B. subtilis*), Gram-negative bacterial strain (*E. coli*) and the antifungal activity against the fungi, *Candida albicans* by Agar- Well Diffusion method. Antimicrobial activity of the complex (**1**) against the microbials is presented in Table 3. It shows strong activity against gram negative bacteria, *E. coli* while no activity against the gram-positive bacteria, *B. subtilis* by taking streptomycin as the reference drug. The antifungal activities of complex (**1**) show promising activity against the fungus, *C. albicans* with reference to the drug Clotrimazole.

**Table 3.** Antimicrobial activity of (**1**) against selected bacterial and fungal strains determined by agar well diffusion method.

| Microorganism                               | Standard drug<br>(100 µg) | Zone of<br>inhibition<br>(mm) | Complex ( <b>1</b> )<br>concentration (µg) | Zone of inhibition<br>(mm) |
|---------------------------------------------|---------------------------|-------------------------------|--------------------------------------------|----------------------------|
| <i>Escherichia coli</i><br>(Gram negative)  | Streptomycin              | 31                            | 250                                        | 14                         |
|                                             |                           |                               | 500                                        | 28                         |
|                                             |                           |                               | 1000                                       | 30                         |
| <i>Bacillus subtilis</i><br>(Gram positive) | Streptomycin              | 30                            | 250                                        | Nil                        |
|                                             |                           |                               | 500                                        | Nil                        |
|                                             |                           |                               | 1000                                       | Nil                        |
| <i>Candida albicans</i>                     | Clotrimazole              | 29                            | 250                                        | 10                         |
|                                             |                           |                               | 500                                        | 21                         |
|                                             |                           |                               | 1000                                       | 28                         |

The results reveal that complex (**1**) exhibit promising antimicrobial activity, with efficacy comparable to that of the standard antimicrobial agents. The observed activity may be attributed to the synergistic influence of several factors, including metal coordination, coordination geometry, enhanced solubility and conductivity, strong metal–ligand covalency, and the formation of an extended multidimensional supramolecular architecture.



**Fig.4** Antimicrobial activity of (1) against (a), gram negative bacteria *Escherichia coli* and (b), fungi *Candida Albicans*

## Conclusion

In conclusion, a new amine-templated cobalt(II) coordination polymer,  $(\{H_3N-(CH_2)_4-NH_3\}[Co(OOC-C_6H_4-COO)_2])_n$  (**1**), has been successfully synthesized via a conventional soft-solution route and comprehensively characterized by spectroscopic, thermal, and single-crystal X-ray diffraction analyses. Structural investigation reveals that the doubly deprotonated 1,2-benzenedicarboxylate ligand functions as an efficient bridging linker between Co(II) centers, leading to the formation of repeated 14-membered cyclic units that propagate into a one-dimensional anionic helical chain architecture. The protonated diammonium cations not only maintain charge neutrality through electrostatic interactions but also play a crucial role in stabilizing the crystal packing through extensive N–H $\cdots$ O hydrogen-bonding interactions, thereby generating a robust three-dimensional supramolecular network. Thermal studies demonstrate the appreciable stability of the coordination polymer, while antimicrobial screening indicates promising activity against selected microbial strains. These findings highlight the potential of the coordination polymer (**1**) as a structurally intriguing and biologically relevant hybrid material.

## Supplementary materials

CCDC 2501196 contain the supplementary crystallographic data for this paper. These data can be obtained free of charge from the Cambridge Crystallographic Data Centre via [www.ccdc.cam.ac.uk/data\\_request/cif](http://www.ccdc.cam.ac.uk/data_request/cif).

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## Disclosure statement

No potential conflict of interest was reported by the author(s).

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