



# Article Spin Canting and Weak Ferromagnetism in a New 2D Coordination Polymer with the Co(II) Chain Bridged by a Single End-to-End Azide

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**Abstract:** By employing semi-flexible multi-*N* donor auxiliary ligands, namely 1,4-bis(5-pyrimidyl)benzene (bpmb) in conjunction with azide, novel Co(II) 2D coordination polymers have been successfully synthesized and structurally characterized, along with magnetic analysis. The resulting compound, {Co(N<sub>3</sub>)(bpmb)(H<sub>2</sub>O)<sub>2</sub>·H<sub>2</sub>O}<sub>*n*</sub> (1), exhibits a unique 2D structure comprised of interconnected Co(II) chains bridged by single end-to-end (EE) azide moieties. These chains are further linked by twisted trans- $\mu_2$ -N,N'-bpmb auxiliary ligands, forming a grid-like network. Additionally, the layers are held together in a 3D arrangement through hydrogen bonding interactions between the coordination water and the N atom of the bpmb ligands. Importantly, magnetic investigations reveal that compound 1 displays weak ferromagnetism attributed to spin canting, with a critical temperature (*Tc*) of 12 K.

**Keywords:** magnetic coordination polymer; single end-to-end azide bridged; weak ferromagnetism; spin canting; metamagnetism



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# 1. Introduction

In recent times, magnetic coordination polymers have garnered significant attention due to their captivating structural diversity [1], as well as their potential applications in high-density information storage technologies [2], quantum computing systems [3], and applications in molecular spintronics [4]. Progress in this field has led to substantial achievements, resulting in the development of various types of molecular magnets, including single-molecule magnets [5], single-chain magnets [6], and single-ion magnets [7]. Additionally, the construction of innovative magnetic units and the use of theoretical simulations have consistently remained focal points in the realm of magnetic chemistry [8,9].

The azide anion,  $N_3^-$ , serves as a three-atom bridge capable of effectively mediating magnetic coupling. In comparison to other compact multitopic ligands such as  $CN^-$  [10],  $OH^-$  [11], and  $C_2O_4^-$  [12], the azide anion offers a range of bridging modes, including (end-on) EO and (end-to-end) EE arrangements, enabling the connection of two or more transition-metal ions into clusters [13–15]. Consequently, the azide anion emerges as a versatile "building block" for the creation of molecular magnetic materials. In most instances, the implementation of a suitable auxiliary ligand, often one with an elongated rod-like or bulky angular structure, is essential to prevent three-dimensional magnetic ordering, thus leading to the formation of low-dimensional magnetic units [16,17]. Given their linear and sturdy bis(primidine) ligand backbone, these ligands represent promising candidates for the exploration of magnetic materials [18].

Moreover, our research group has consistently delved into the coordination chemistry of bis(pyrimidine) ligands, as they have proven to be promising candidates for the development of magnetic materials due to their strong coordination affinity [19,20]. In line with these considerations, this study presents a novel two-dimensional coordination polymer

achieved by incorporating  $N_3^-$  into systems involving divalent Co ions and the ligand 1,4-bis(5-pyrimidyl)benzene (bpmb).

## 2. Results and Discussion

### 2.1. Syntheses and Characterization of Compound 1

Compound **1** was successfully synthesized via a self-assembly reaction involving the reaction of  $Co(NO_3)_2$  salts, the NaN<sub>3</sub> ligand, and the bpmb ligand at a 1:1:1 Co:N<sub>3</sub>:bpmb molar ratio. This reaction was carried out in a mixed solvent consisting of acetone and H<sub>2</sub>O at a temperature of 50 °C. The phase purity of a bulk sample of compound **1** was further verified through X-ray powder diffraction (XRPD) patterns and elemental analysis. The XRPD pattern of compound **1** matches the pattern simulated from the single-crystal data, confirming its structural integrity (see Figure S1 in the Supporting Information). Still, there were differences in peak intensities and also additional Bragg peaks, the latter indicating unknown phases.

The thermal stability of compound **1** was assessed via TG analysis (see Figure S2). The TG curve revealed a one-step process involving the removal of water, resulting in a total weight loss of 11.8% in the temperature range of 90–150 °C. This corresponds closely to the calculated value of 11.9%, representing the loss of one solvated and two coordinated water molecules. Beyond approximately 220 °C, the host framework began to decompose, leading to a rapid weight loss. This decomposition is attributed to the breakdown of the bpmb ligand.

In the IR spectrum, a prominent and broad absorption peak observed at around 2097 cm<sup>-1</sup> can be attributed to the vibrations of  $N_3^-$  ions. Additionally, strong bands spanning the 1631–1572 cm<sup>-1</sup> range were assigned to the vibrations of C=C and C=N groups within the bpmp ligand.

## 2.2. Description of Structure of $\{[Co(N_3)(bpmb)(H_2O)_2](NO_3) \cdot H_2O\}_n$ (1)

X-ray diffraction analysis reveals that compound **1** crystallizes in the monoclinic space group *Cc* and features a 2D layered structure. This structure is constructed from Co(II)azide inorganic chains interconnected by ditopic bpmb ligands. Within the asymmetric unit, there exists one crystallographically independent Co(II) ion, one bpmb ligand, two coordination water molecules, one NO<sub>3</sub><sup>-</sup> ion, and one solvated water molecule.

In Figure 1, the Co(II) ion adopts a distorted *trans*- $CoN_4O_2$  octahedral geometry, comprising four equatorial nitrogen atoms from two bpmb ligands (N1 and N4) and two EE-azide ions (N5 and N7). Additionally, the two axial oxygen atoms (O1 and O2) correspond to two coordination water molecules. Consequently, each Co(II) ion is connected to its neighbors via single EE-N<sub>3</sub> bridges, creating an infinite 1D Co-azido-based chain along the *b*-axis, with EE-N<sub>3</sub> distances spanning 6.013 Å (Figure 2a).



**Figure 1.** The coordination environments of compound 1. The NO<sub>3</sub><sup>-</sup> anion, the solvated water molecule and the H atoms have been omitted for clarity. (Symmetry code: (A) -0.5 + x, 0.5 - y, -0.5 + z; (B) x, -1 + y, z; (C) -0.5 + x, 0.5 - y, -0.5 + z).



**Figure 2.** (a) The single-EE-N<sub>3</sub> bridged Co(II) chain, and the zigzag arrangement of bpmb ligands in a 2D layered structure of **1**, and (b) the H-bonging (black dashed line) connected 3D supramolecular network of compound **1** along the *b* axis, and the NO<sub>3</sub><sup>-</sup> anions and the solvated water molecules encapsulated in the 1D channel.

Within this chain, the slightly distorted CoN<sub>4</sub>O<sub>2</sub> octahedron exhibits Co(II)–O/N bond lengths ranging from 2.061(2) to 2.162(3) Å. The cis and trans bond angles around the Co(II) centers vary between 87.42(10)° and 91.57(11)°, and 177.75(12)° and 178.81(10)°, respectively. Furthermore, the two bridging Co–N–N angles measure 129.2(3)° and 132.9(3)°, while the unique torsion angle of Co–NNN–Co is 1.2°. These molecular geometries closely resemble those observed in other compounds featuring a Co-azide chained structure [21–23].

In compound **1**, the bpmb ligand exhibits twisted conformations, characterized by dihedral angles of 27.69° and 32.29° between the pyrimidyl ring and the benzyl ring (Scheme 1). It serves as a *trans-* $\mu_2$ -N,N'-ditopic linker, effectively connecting the Co(II)-azide inorganic chains along the [101] direction and extending the structure into 2D inorganic–organic hybrid layers, as illustrated in Figure 2b. Within these layers, the Co…Co distance bridged by bpmb ligands measures 13.58 Å.



**Scheme 1.** The twisted *trans*- $\mu_2$ -N,N'-bpmb in compound **1**.

Furthermore, the coordination orientation of the pyrimidyl groups within the bpmb ligands complements the slanted orientation of the metal coordination sphere. This arrangement results in a zigzag configuration of bpmb ligands within the layer. Consequently, the layer displays significant undulations due to the slanted disposition of bpmb ligands concerning the M···M line.

Additional hydrogen bonding interactions involving the coordinated water molecules and the uncoordinated nitrogen atoms of the bpmb ligands between adjacent layers result in a 3D supramolecular network, characterized by the shortest interlayer Co···Co distance of 7.62 Å (see Figure 2b). The hydrogen bond distances are O1···N2 = 2.878 Å and O2···N3 = 2.799 Å, with corresponding angles of O1–H1A···N2 = 169.34° and O2–H2B···N3 = 124.16°.

Within this network, the  $\mu_2$ -bpmb ligands in each layer are arranged in an overlapping manner, forming infinite 1D arrays along the b-axis. These arrays partition the interlayer space into 1D channels along the c-direction, with NO<sub>3</sub><sup>-</sup> anions and water molecules encapsulated within these channels.

# 2.3. Magnetic Properties

Variable temperature DC magnetic susceptibility data were gathered for a powdered sample of compound **1** within a 1 kOe magnetic field over the temperature range of 2.0–300 K, and these results are presented as a plot of  $\chi_M T$  versus *T* in Figure 3. At 300 K, the  $\chi_M T$  value measures 3.15 cm<sup>3</sup> mol<sup>-1</sup> K, exceeding the expected value for a high-spin Co(II) ion (1.87 cm<sup>3</sup> mol<sup>-1</sup> K with g = 2.0). Upon cooling, the  $\chi_M T$  values gradually decrease and exhibit a cusp at approximately 12 K, with a  $\chi_M T$  value of 0.63 cm<sup>3</sup> mol<sup>-1</sup> K. Subsequently, the  $\chi_M T$  value sharply drops to 0.09 cm<sup>3</sup> mol<sup>-1</sup> K at 2.0 K.



**Figure 3.** Temperature dependence of  $\chi_M T$  ( $\blacksquare$ ) and  $\chi_M^{-1}$  ( $\Box$ ) of compound **1** at temperatures between 2 to 300 K with a 1 kOe applied field. The solid lines correspond to the best fit (see the text). The inset shows the  $\chi_M T$  vs. T plots of **1** below 20 K ate the indicated fields.

The data for temperatures above 100 K adhere to the Curie–Weiss law, displaying a Curie constant  $C = 4.13 \text{ cm}^3 \text{ mol}^{-1}$  K and a Weiss constant  $\theta = -110.9$  K. The continuous reduction in  $\chi_M T$  from 300 K to 30 K can be attributed to both the spin-orbit coupling of the octahedral Co(II) ions and the moderate antiferromagnetic coupling within compound 1. The sudden increase in  $\chi_M T$  at temperatures below 30 K suggests the presence of weak ferromagnetism resulting from spin canted antiferromagnetism. Furthermore, the rapid decline in  $\chi_M T$  at temperatures below 14 K may be attributed to saturation effects and/or antiferromagnetic interactions.

To illustrate the spin canting in the low-temperature range, the temperature-dependent  $\chi_M T$  at various magnetic fields was collected and depicted in the inset of Figure 3. Below 14 K, there are notable abrupt increases in  $\chi_M T$  values, and this behavior is field-dependent. For instance, at a small field of 10 Oe, the  $\chi_M T$  undergoes an abrupt rise to a maximum value of 1.99 cm<sup>3</sup> mol<sup>-1</sup> K at 12 K. This observation confirms the occurrence of spin canting in compound **1**, with the upturn in  $\chi_M T$  below 14 K indicating uncompensated magnetic moments arising from spin canted antiferromagnetism.

In the context of the structure of complex 1, the system can be considered as an infinite uniform chain where the magnetic coupling is facilitated through the single EE-azide bridges. Interactions between chains mediated by the long organic ligand and hydrogen bonds are exceedingly weak, making them negligible in this system. Consequently, the interaction (*J*) through the double bridge can be evaluated using two fitting models for distinct temperature ranges. For the high-temperature range of 40–300 K, the Fisher

1D chain model (S = 3/2) was applied to the susceptibility data. This model utilizes a conventional equation for a uniform chain of classical spins based on the Hamiltonian [24]:

$$\hat{H} = -J \sum_{i=1}^{n} \hat{S}_{i} \cdot \hat{S}_{i+1}$$
(1)

$$x_M = \frac{N_A g^2 \beta^2 S(S+1)}{3kT} (\frac{1+u}{1-u})$$
(2)

where *u* is the well-known Langevin function defined as u = coth [JS(S + 1)/kT] kT/[JS(S + 1)], and  $\beta$  ia Bohr magnetron. The best simulation leads to J = -17.5(3) cm<sup>-1</sup> and g = 2.85(1) with  $R = 1.37 \times 10^{-3}$  (Figure 3, black line). The fitting results indicate antiferromagnetic interaction (*J*) between Co(II) ions through EE-N<sub>3</sub><sup>-</sup> bridges. The antiferromagnetic nature of the magnetic coupling of *J* is consistent with results for related Co-NNN-Co compounds [25–27]. It has been reported that the Co(II) ions through single EE-azido bridges are coupled from antiferromagnetic to ferromagnetic depending on the torsion angle of Co-NNN-Co. The larger the torsion angle of Co-NNN-Co, the stronger ferromagnetic coupling due to the accidental orthogonality of magnetic orbitals. In compound 1, the antiferromagnetic coupling is assumed from the very small Co-NNN-Co torsion angle of 1.2°.

To further characterize the low-temperature magnetic behavior of compound **1**, zero-field-cooled (ZFC) and field-cooled (FC) magnetization measurements were conducted under a magnetic field of 20 Oe. As depicted in Figure 4, the ZFC magnetization initially increases as the temperature rises from 2.0 K, reaching its maximum at 12 K, and then rapidly decreases, indicating the presence of an antiferromagnetic intrinsic state. Upon cooling, the FC magnetization curve exhibits a rapid increase and diverges from the ZFC curve around 12 K, signifying the onset of long-range magnetic ordering below Tc = 12 K.



**Figure 4.** The temperature dependence of ZFC and FC magnetization of compound **1** in an applied field 10 Oe.

The existence of magnetic ordering was further validated through ac magnetic susceptibility measurements at various frequencies under  $H_{dc} = 0$  Oe and  $H_{ac} = 3.5$  Oe, as shown in Figure 5. Both in-phase ( $\chi_M'$ ) and out-of-phase ( $\chi_M''$ ) signals remain frequency-independent. The  $\chi_M'$  signals exhibit a peak with a maximum at 9.0 K, while the nonzero

 $\chi_{\rm M}''$  signals rapidly increase at temperatures below 12 K. These results align with the ZFC/FC magnetization data and provide additional confirmation of the presence of antiferromagnetic ordering below *T*c = 12 K.



**Figure 5.** In phase ( $\chi'$ ) and out-off phase ( $\chi''$ ) of the ac magnetic susceptibilities in a zero applied dc field and a 3.5 G ac field at the indicated frequencies for compound **1**.

Moreover, isothermal magnetization measurements up to 70 kOe were carried out for compound **1** at 2.0 K, and the results are presented in Figure 6a. The magnetization curve (*M*) exhibits a slightly sigmoid shape, where M increases slowly and linearly at fields below ~3.5 kOe. Beyond this point, there is a sharp increase in the range of 3.5–5.0 kOe, followed by a gradual increase, reaching a maximum value of 0.41 N $\beta$  at 70 kOe. This value remains significantly below the anticipated saturation value of 2–3 N $\beta$  for an isotropic high-spin Co(II) system, thus confirming the antiferromagnetic nature of **1**. The sigmoid shape of *M* strongly suggests the presence of a field-induced metamagnetism, wherein weak antiferromagnetic couplings, resulting in antiparallel alignments of net moments, are overcome by an external critical field. This transition is accompanied by a shift from an antiferromagnetic state (AF) to a paramagnetic state (P).

The gradual increase in magnetization at fields below ~3.5 kOe implies the existence of antiferromagnetic couplings between the Co(II)-EE-N<sub>3</sub> chains, likely mediated by hydrogen bonds within the layers. Conversely, the rapid increase in magnetization at fields above ~3.5 kOe suggests the overcoming of interchain antiferromagnetic couplings by the applied field. At 2.0 K, the critical field ( $H_C$ ) for the magnetic phase transition of compound 1 is estimated to be approximately 3.66 kOe by analyzing dM/dH (refer to Figure 6a, inset). In the literature, metamagnetic behavior has been reported in layered or chain compounds exhibiting competing magnetic interactions and strong magnetic anisotropy [28–35].

Additionally, when the field is less than 7 kOe, a hysteresis loop is clearly observed for compound **1** at 2.0 K, indicative of its soft magnetic properties (see Figure 6b). Within this hysteresis loop, a remnant magnetization (*M*r) of  $\approx 0.0022 N\beta$  and a coercive field of  $\approx 230$  Oe are observed. By extrapolating from the remnant magnetization measured at 2.0 K, the canting angle of **1** is estimated to be approximately  $0.06^{\circ}$  [36].



**Figure 6.** (a) Field dependence of the magnetization (empty blue square) of **1** at 2.0 K (the inset shows the plot of dM/dH vs. *T*, red dot) and (b) the blow-up of the hysteresis loop (filled blue square).

In general, spin canted behavior typically originates from two underlying factors: (1) the emergence of an antisymmetric exchange known as the Dzyaloshinskii–Moriya interaction and (2) the presence of single-ion magnetic anisotropy. The presence of an inversion center between adjacent spin centers can lead to the absence of the antisymmetric exchange. Considering the structural characteristics of compound 1, even though the Co(II) ions of adjacent spins are related to a crystallographic inversion center, they are interconnected by  $2_1$  helices with opposing chiralities through EE-N<sub>3</sub> groups. The diverse orientations resulting from these opposing chiralities can give rise to the presence of the antisymmetric exchange, thus leading to the observed spin canted behavior. Furthermore, the distortion of the octahedral Co(II) site may exhibit significant anisotropy, further contributing to the spin canting observed in compound 1. A compound with a similar single EE-N<sub>3</sub> chain motif has been reported, in which the spin canting Co(II)-EE-N<sub>3</sub> chains are separated by the long organic ligands, resulting in a single-chain magnetic behavior [37].

# 3. Experimental

# 3.1. Materials and Methods

Reagents and solvents were obtained commercially and used without further purification. The synthesis of bpmb followed the established procedure in the literature [38]. It is essential to exercise extreme caution when working with azido compounds, as they have the potential to be explosive. Hence, these compounds should only be synthesized and handled in small quantities and always treated with the utmost care and precaution.

# 3.2. Synthesis of $\{[Co(N_3)(bpmb)(H_2O)_2](NO_3) \cdot H_2O\}_n$ (1)

A solution of Co(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O (87.4 mg, 0.30 mmol) in water (10 mL) was added into a mixture of bpmb (72.3 mg, 0.30 mmol), and NaN<sub>3</sub> (20.1 mg, 0.33 mmol) in a mixed solution (acetone 30 mL/water 20 mL). After stirring for 10 min, the resulting solution was allowed to stand at 40 °C. Red needle crystals suitable for single-crystal X-ray diffraction analysis of **1** were formed in a week. The crystals were washed with water and acetone, collected by suction filtration and dried in air. Yield: 88% (based on bpmb). A powder X-ray diffraction pattern of the bulk sample compared well with the pattern simulated from the single-crystal data (vide infra). Anal. Calcd for  $C_{14}H_{16}CoN_8O_6$  (1): C, 37.40; H, 3.44; N, 24.75. Found: C, 37.26; H, 3.57; N, 24.83. IR data (KBr disk, cm<sup>-1</sup>): 3168(br, s), 2097 (vs), 1631(w), 1590(w), 1572(s), 1449(w), 1418(s), 1383(vs), 1357(vs), 1336(sv), 1181(m), 1042(w), 1010(m), 922(w), 840(m), 714(s), 658(s), 576(w).

# 3.3. X-ray Crystallography

Diffraction data of compound **1** were collected on a Bruker D8 Venture PHOTON III diffractometer (Bruker, Karlsruhe, Germany) with graphite-monochromated Mo-K $\alpha$  radiation ( $\lambda = 0.7107$  Å). Data collection temperature was controlled at 110 K with open flow of N<sub>2</sub> cryostreams. Empirical absorption corrections were applied using the SADABS program [39]. The SHELXTL-2018 program was used to solve and to refine the structure by direct methods with a racemic twin and the full-matrix least-squares method, respectively [40]. The atomic displacement parameter of all non-hydrogen atoms was refined anisotropically. The hydrogen atoms of the coordinated water molecule were located from differential electron density maps, whereas the hydrogen atoms of the bpmp ligand were constrained to the ideal positions riding on their parent atoms with isotropic thermal parameters. A summary of data of compound **1** is presented in Table 1, and selected bond lengths and angles are given in Table 2.

Formula	C <sub>14</sub> H <sub>16</sub> CoN <sub>8</sub> O <sub>6</sub>	
Fw	451.28	
Crystal system	Monoclinic	
Space group	Сс	
a/Å	14.0163(4)	
b/Å	6.0132(2)	
c/Å	20.9136(6)	
α/°	90	
$\beta/^{\circ}$	91.6740(10)	
$\gamma/^{\circ}$	90	
V/Å <sup>3</sup>	1761.90(9)	
Z	4	
T/K	110(2)	
$Dc/g cm^{-3}$	1.701	
$\mu/\mathrm{mm}^{-1}$	1.029	
R <sub>int</sub>	0.0241	
$ heta_{\max}/^{\circ}$	34.983	
Goodness-of-fits on $F^2$	1.030	
$R_1^1$ , w $R_2^2$ (all data)	0.0257, 0.0565	
$R_1^{1}$ , w $R_2^{2}$ (I > 2 $\sigma$ (I))	0.0260, 0.0566	
Flack	0.490(14)	

Table 1. Crystallographic data for compound 1.

 $\frac{1}{R_1} (\Sigma | |F_0| - |F_C| |) \Sigma |F_0|;^2 wR_2 = [\Sigma w |F_0^2 - F_C^2|^2 \Sigma w(F_0^4)]^{1/2}.$ 

<b>indice 2.</b> Delected Dona distances (11) and angles (1) for compounds 1.
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Compound 1			
Co(1)–O(2)	2.061(2)	Co(1)–N(7)	2.111(3)
Co(1)–O(1)	2.085(2)	Co(1)–N(1)	2.152(3)
Co(1)–N(5)	2.103(2)	Co(1)–N(4)	2.162(3)
O(2)–Co(1)–O(1)	178.81(10)	N(5)-Co(1)-N(1)	94.87(10)
O(2)–Co(1)–N(5)	87.42(10)	N(7)-Co(1)-N(1)	87.13(11)
O(1)–Co(1)–N(5)	91.46(10)	O(2)–Co(1)–N(4)	92.35(9)
O(2)–Co(1)–N(7)	91.57(11)	O(1)-Co(1)-N(4)	87.17(10)
O(1)–Co(1)–N(7)	89.53(11)	N(5)-Co(1)-N(4)	86.35(10)
N(5)–Co(1)–N(7)	177.75(12)	N(7)-Co(1)-N(4)	91.69(10)
O(2)–Co(1)–N(1)	89.56(10)	N(1)-Co(1)-N(4)	177.78(12)
O(1)–Co(1)–N(1)	90.95(9)	N(6) <sup>1</sup> –N(7)–Co(1)	132.9(3)
N(6)-N(5)-Co(1)	129.2(3)		

Symmetry transformations used to generate equivalent atoms:  $^{1} x, y + 1, z$ .

#### 3.4. Physical Measurements

IR spectra were recorded using a Perkin-Elmer Spectrum RX1 FTIR spectrometer, and KBr pellets (Elementar, Langenselbold, Germany) were employed as the sample medium. Elemental analysis for carbon (C), hydrogen (H), and nitrogen (N) was conducted using an Elemental varioEL III elemental analyzer (Seiko Instruments, Chiba shi, Japan). Thermogravimetric (TG) analysis was carried out using an EXSTAR 6200 TG/DTA thermal analyzer (Seiko Instrumental, Inc.) under a nitrogen atmosphere, employing a heating rate of 5 °C/min. Powder X-ray diffraction data were collected using a Rigaku D/max 2000 diffractometer (Rigaku Instruments, Tokyo, Japan) at room temperature, utilizing Cu-K $\alpha$  (wavelength,  $\lambda = 1.5406$  Å) radiation. Direct current (DC) and alternating current (ac) magnetic susceptibility measurements of microcrystalline samples of compound **1** were performed on a Quantum Design MPMS-7 SQUID magnetometer and a PPMS magnetometer, respectively (Quantum Design, San Diego, CA, USA). Experimental magnetic susceptibility data were adjusted for diamagnetic contributions, which were estimated from the background of the sample holder and Pascal's constants [41].

### 4. Conclusions

The incorporation of a semi-flexible N-donor ligand, 1,4-bis(5-pyrimidyl)benzene (bpmb), has enabled the synthesis of a novel 2D Co(II)-azido coordination polymer. The structure of compound **1** is characterized by single end-to-end (EE) azide-bridged Co(II) chains and linear, twisted  $\mu_2$ -bpmb auxiliary linkers. Magnetic investigations have revealed that compound **1** exhibits weak ferromagnetic behavior and magnetic ordering attributed to spin canting, with a critical temperature ( $T_C$ ) of 12 K. Additionally, the compound demonstrates field-induced magnetic transitions associated with metamagnetism below  $T_C$ . These findings highlight the potential of utilizing semi-flexible ligands like 1,4-bis(5-pyrimidyl)benzene derivatives in the synthesis of coordination polymers, enabling the creation of polymeric networks with diverse topological structures and bulk magnetic properties.

**Supplementary Materials:** The following supporting information can be downloaded at: https: //www.mdpi.com/article/10.3390/inorganics11110444/s1, Figure S1: Simulated PXRD pattern (red) and experimental PXRD pattern (black) of compound **1**, Figure S2: Thermogravimetric (TG) analysis diagram of compound **1**.

**Author Contributions:** C.-I.Y. conceived and designed the experiments and wrote the paper; Y.-L.K. performed the experiments; H.-K.L. contributed to the single-crystal X-ray data collection and structural analysis. All authors have read and agreed to the published version of the manuscript.

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**Data Availability Statement:** The data presented in this study are available in the manuscript and Supplementary Material.

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