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ORIGINAL ARTICLE

Two Co(II) coordination polymers: Magnetic properties and treatment activity on cochlear ischemia reperfusion injury (CIRI) by reducing inflammatory response

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KEYWORDS

Coordination complexes; Magnetic properties; Cochlear ischemia reperf sion injury

ct In the o ent study, under conditions of solvothermal reaction, two coordination poly-**(**), nameley, $\{[Co(TZMB)(1,4-bipb)(H_2O)]\cdot H_2O\}_n$ (1) and $\{[Co_2(TZMB)_2(H_2O)(DMA)]\cdot$ mers 🔪 have been obtained with or without using the pyridine ancillary linker 1,4-bis(pyrid- DMA_n 4-yl)benzen, 4-bipb) via utilizing Y-type N-heterocyclic carboxylic acid 4,4'-(1H-1,2,4-triazol-1-y 1) methylene-bis(benzoic acid) (H_2TZMB). From the magnetic researches, the antiferromagnetic couping between contiguous metal ions exists in compounds 1 and 2. The treatment effect of comds 1 and 2 against the cochlear ischemia reperfusion injury (CIRI) was assessed and the related cchanism was explored at the same time. Firstly, the ELISA detection was conducted to determine the influence of the new compounds on the releasing of inflammatory cytokines by the inner ear endothelium. Next, the relative expression levels of genes related with ROS production in the inner ear endothelium was assessed by the real time RT-PCR detection.

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1. Introduction

According to statistics from the China Disabled Persons' Federation, to the end of 2016, there were 32.194 million people with a certificate in our country, most of whom were sensorineural deafness. Inner ear blood flow and microcirculation disorder is the main factor leading to the occurrence sensorineural deafness, especially cochlear ischemia reperfusion

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1878-5352 © 2021 The Authors. Published by Elsevier B.V. on behalf of King Saud University. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/). injury (CIRI) [1–2]. At present, the therapeutic drugs that used in clinical or in clinical trials mainly include sodium thiosulfate, lipoic acid, acetylcysteine, aspirin, batroxobin and glucocorticoids, etc. But their mechanism of action is still need to be explored, and long-term usage has large side effects, and the overall effect is not satisfactory [3]. In recent years, new candidates' development has attracted attention of researchers because of its stable curative effect, fewer side effects, and multi-target onset.

Coordination polymers (CPs), as a hot topic in functional materials, have drawn tremendous interest, one of which is due to their diverse composition and particular structural tailoring abilities, and the other is due to their attractive uses in luminescence, electrochemical sensing as well as adsorption separation, etc [4-7]. Their different assembly approaches and numerous components determine the diversity of their characteristics and structures, which are directly connected with the coordination properties of the components, for instance, number of dentates, steric hindrance of the ligands, charge as well as types and positions of substituents [8–11]. Numerous CPs with amusing topologies have been reported. but in the field of crystal engineering, how to control the accurate structures of CPs is also a huge challenge [12–15]. In this study, we selected 4,4'-(1H-1,2,4-triazol-1-yl)methylene-bis(be nzoic acid) (H₂TZMB) to be a multifunctional organic ligand on the basis of the next superiority: (i) the H_2TZMB ligand possesses a variety of coordination patterns and multiple coordination sites, which are conducive to construct multidimensional structures; (ii) the mixture of carboxylate donor portions and triazole of the H₂TZMB ligand may have potential to transfer magnetic exchange and produce intrig 'ng magnetic performance; (iii) the H₂TZMB ligand shows excellent electron-transferring ability because it h in ele trons [16–19].

Based on the above discussions, in the study, der the nati solvent-thermal reaction condition, two cool лрогу (CPs), namely, $\{[Co(TZMB)(1,4-bir_2)(H_2O)]\} \in C$ $\{[Co_2(TZMB)_2(H_2O)(DMA)] \cdot DM = 120, have b with or without using the pyrime a sillary links$ O_{n} (1) and obtained illary linker, 1,4-bis (pyrid-4-yl)benzene (4-bipb) Through In pectroscopy, powder X-ray diffraction (PXD), single-crystal ray diffraction, single crystal X-ray diffraction, thermogravimetric (TG) analysis and the elemental malysis both as-synthesized polymers crized. A ording to the magnetic have been absolutely cha researches, the mun romage tic coopling between contiguous ompound and 2. Serial experiments metal ions sists in were concreted f detection of compounds' biological of the ELISA assay showed that compound activity. The 1 showed a multiprominent effect on inhibiting the levels of IL-6 and IL-18 compound 2. In addition to this, the results of real time RT-PCR also exhibited compound 1 was much stronger than compound 2 on reducing the relative expression of ROS relevant genes.

2. Experimental

2.1. Chemicals

All laboratory drugs were purchased directly from the market and utilized without manipulation in accordance with the medicines themselves. The 1,4-bis(pyrid-4-yl)benzene and 4,4'-(1*H*-1,2,4-triazol-1-yl)methylene-bis(benzoic acid) ligands were obtained from Jinan Henghua Chemical reagent company and used as received.

2.2. MeasurementsC

By using the Nicolet (Impact 410) spectrometer, we recorded IR absorption spectra of the compounds between 400 and 4000 cm⁻¹ with samples of 5 mg per 500 mg KBr pellets. Through the analyzer of Perkin–Elmer 240C element, N, H as well as C analysis were investigated. Through Cu–K α radiation ($\lambda = 1.5418$ Å), the measurements of powder X-ray diffractometer, and the operang wage of X-ray tube were 40 kV along with 40 mA. Menen the tenerature of thermal analyzer reaches 973 K at a neating rate on 10 K per minute in the nitrogen at losphere via the Perkin-Elmer thermogravimetric analyzer Pyris 1 CGA are characterized the as-synthesized samples through therm gravimetric analysis (TGA). Via the PPM-P AC are magnetic properties were measured. The emagnetism of the whole component atoms is corrected by unusing Pascal's constants.

2. Equation and correcterization for $\{[Co(TZMB)(1,4-b)(H_2O)] \cdot H_2O\}_n$ (1) and $\{[Co_2(TZMB)_2(H_2O)(DMA)] \cdot MA\}_n$ (2) (where 1)

Th pixture namely, Co(NO₃)₂·6H₂O with 0.008 mmol and 3 mg, raOH aqueous solution using 0.20 mol L^{-1} and L, H₂TZMB which is 0.004 mmol and 1.3 mg as well as 1,4-bipb with 0.004 mmol and 0.9 mg was added into 2 mL H₂O/EtOH (v/v = 1/1) mixed solution, which was placed into a stiff glass tube that could withstand high pressure. Afterwards, the mixture was heated for 80 h at 393 K and then slowly cooled to 303 K. Then, the product was filtered and washed with distilled water and dried in a natural environment to obtain pink needle-like crystals of 1, and on the basis of Co, their yield is 44%. The analysis of element: calcd (found) % for C₃₃H₂₇N₅CoO₆ (1): C, 61.12 (61.33); H, 4.20 (4.45); N, 10.80 (10.43). IR (KBr, cm⁻¹): 779 (m), 870 (w), 997 (m), 1112 (s), 1345 (s), 1557 (vs), 1664 (s), 3129 (w), 3442 (w).

Co(NO₃)₂·6H₂O with 0.008 mmol and 3 mg, NaOH aqueous solution using 0.20 mol L⁻¹ and 0.15 mL, H₂TZMB which is 0.15 mL and 1.6 mg as well as H₂O/CH₃CH₂OH/DMA (1 mL, V:V:V = 2:1:1) were mixed into a stiff glass tube. Afterwards, the mixture was heated for 60 h at 358 K and then slowly cooled to 303 K. Then, the product was filtered and washed with distilled water and dried in a natural environment to obtain pink diamond-like crystals of **2**, and on the basis of Co, their yield is 47%. The analysis of element: calcd (found) % for C₄₂H₄₂Co₂N₈O₁₁: C, 52.95 (53.25); H, 4.44 (4.48); N, 11.76 (11.78). IR (KBr pellet, cm⁻¹): 821 (w), 1137 (w), 1274 (w), 1390 (s), 1515 (m), 1552 (m), 1616 (s), 1652 (m), 1688 (s), 2352 (w), 3102 (w), 3382 (w).

2.4. Single crystal X-ray diffraction studies

Using a SuperNova diffractometer, the X-ray data were acquired. We could analyze strength data via CrysAlisPro



{[Co₂(TZMB),/_20)(DMA)·DMA,



software, and then transform the data of intensity into HKL files. Based on immediate way, the incipient structural models were created through the SHELXS program. Similarly, we modify models via SHELXL-2014 program according to the least-squares way. The entire non-H atoms were blended with anisotropic parameters. After that, according to the AFIX commands, the intact hydrogen atoms are geometrically to carbon atoms to which they are attached. The crystallograp to parameters and refinement details for those two complexes a exhibited in table 1.

2.5. ELISA detection

After the construction of animal model and co and treatment, the IL-6 and IL-18 levels rei used by the inner ear endothelium into the lymphatic and as determine with ELISA assay. This conduction was finish totally under the guidance of the instructions zeron some modifications. In short, general-grade guinea pig week-old, 220-250 g half male and half male) used in this earch y re provided by the Laborait of Chargqing Academy of tory Animal Research h prese mation vas authorized by the Chinese Medicin e of C. n Ing Academy of Chinese Animal Ethics ommi ¹/₂ Fecl was used for the thrombosis Medicine. en, the tb OTOKIN, was given for thrombolysis. formation, a After that, com, unds 1 and 2 were employed for specified treatment at the conventration 5 mg/kg, the ligands of compounds 1 and 2 were ven for treatment at the same concentration. Finally, we gathered the lymphatic fluid of inner ear was collected, and the IL-6 and IL-18 levels was detected by ELISA detection kit.

2.6. Real time RT-PCR

The real time RT-PCR was carried out in this present research to determine the relative expression of gp91 and gp22 in the inner ear endothelium after indicated compound treatment. This preformation was finished totally under the guidance of the protocols with a few modifications. Briefly, general-grade

 Table 1
 The crystor ographic parameters as well as refinement detailer Scomplexes 1 and 2.

Id Atification code	1	2
Inpirical formu	C132H108C04N20O24	C ₁₆₈ H ₁₆₈ Co ₈ N ₃₂ O ₄₄
F mula weight	2594.10	3810.78
Ten, rature/K	124.3(5)	293.15
Crysta	orthorhombic	monoclinic
ce group	Pbcn	C2/c
A	26.5293(11)	45.6293(11)
b/Å	8.8594(3)	9.8126(2)
c/Å	25.7420(11)	21.3369(3)
$\alpha/_{\circ}$	90	90
β/°	90	109.274(2)
γ/°	90	90
Volume/Å ³	6050.2(4)	9018.0(3)
Z	2	2
$\rho_{calc}g/cm^3$	1.424	1.403
μ/mm^{-1}	0.621	0.802
Data/	5305/72/447	8972/273/671
restraints/parameters		
Goodness-of-fit on	1.170	1.032
F^2		
Final R indexes	$R_1 = 0.0875,$	$R_1 = 0.0911,$
$[I > = 2\sigma (I)]$	$\omega R_2 = 0.1824$	$\omega R_2 = 0.2500$
Final R indexes [all	$R_1 = 0.1052,$	$R_1 = 0.1179,$
data]	$\omega R_2 = 0.1929$	$\omega R_2 = 0.2727$
Largest diff.	1.09/-0.92	1.25/-0.84
peak/hole / e Å ⁻³		
CCDC	2,069,060	2,069,061

guinea pig (4-week-old, 220–250 g, half male and half male) used in this research were provided by the Laboratory Animal Research Institute of Chongqing Academy of Chinese Medicine. This preformation was authorized by the Animal Ethics Committee of Chongqing Academy of Chinese Medicine. Then, the 40% Fecl was used for the thrombosis formation, and the Urokinase was given for thrombolysis. After that,

compounds 1 and 2 were employed for specified treatment at the concentration 5 mg/kg, the ligands of compounds 1 and 2 was given for treatment at the same concentration. After treatment, the inner ear endothelium in the mice were isolated and RNA in the cells was extracted with TRIZOL reagent. The quality and quantity of RNA was measured, and which was then reverse transcribed into cDNA. Finally, gp91 and gp22 in inner ear endothelium were determined by real time RT-PCR. $2^{-\Delta\Delta CT}$ was used for statistical analysis.

3. Results and discussion

3.1. Crystal structures

By using NaOH as the pH modulator, a mixture, namely, Co (NO₃)₂·6H₂O, H₂TZMB as well as 1,4-bipb, reacted in the mixed solvent of H₂O along with EtOH to obtain the compound 1. According to the data of single crystal gathered in the natural environment, the results of purification and structural solution demonstrate that the compound 1 crystallizes in an orthorhombic system with a space group of Pbcn and demonstrates a three-dimensional framework. In Fig. 1a, one $TZMB^{2-}$ ligand, one coordination, one Co^{2+} ion, one lattice water molecule as well as one coordinated 1,4-bibp constitute the asymmetric unit of 1. One nitrogen atom from the triazole ring of $TZMB^{2-}$ ligand [Co1–N3B = 2.077(0) Å], both oxygen atoms which are from both $TZMB^{2-}$ ligands [Co1–O3A = 2. 094(0) Å, Co1–O1 = 2.067(0) Å], one oxygen atom which are from a water molecule [Co1-O1W = 2.078(8) Å] as well as two nitrogen atoms which are from 1,4-bipb $[Co1-N4 = 2.1, v_{c}]$ Å, Co1–N5C = 2.135(7) Å] encircle every Co^{2+} ion. The a1 environment of the Co²⁺ center can be described as a twist

{CoO₃N₃} octahedral geometry (OC-6) according to the continuous shape measure (CShM) value obtained for that geometry: S(OC-6) = 0.544. The 1's H₂TZMB ligands are completely deprotonated in a coordination pattern of (κ^1 - κ^0)- κ^1 -(κ^1 - κ^0)- μ^3 (Fig. 1b). The carboxylic groups of TZMB²⁻ ligands are entirely connected with Co ions in a bridged coordination pattern of (μ_1 - η^1 : η^0) to construct a two-dimensional [Co(TCMB)]_n network, which constructs a three-dimensional framework through being connected with a one-dimensional [Co(1,4-bipb)]_n zigzag chain (Fig. 1c). In Fig. 1d, the 1's framework can be simplified as a 2-nodal (3,5) connection network with {4-6·8}{4-6⁴·8⁵} point symbol through topology, and the 3-c nodes and the 5-c nodes are the two representations of the TZMB²⁻ ligands and the central contents. The structure of complex 1 is similar to that goine Mn(h) based coordination polymer constructed from the same organic ligand [9]. According to the single rystant ray diffraction study, the compound 2 crystallizers an monotonic system with a space

According to the single rystable ray diffraction study, the compound **2** crystallizes of an monochic system with a space group of C2/c and demonstrates a three amensional frame. One coordinated where morecule, two Co ions, one lattice DMA molecule one commutation as well as two TZMB²⁻ ligands construct the asymmetric unit of **2** (Fig. 2a). One nitrogen nome on the triax ring of the TZMB²⁻ ligand (N3I), five carbonalic oxygen atoms from four TZMB²⁻ ligant 1099K, O8K, 16, O4J, O1A) encircle each Co1A ion, this demonstrating a twisted {CoO₅N} octahedral geometry. O2 is located in a twisted {CoO₅N} octahedral geometry d is connect d with one oxygen atom from the H₂O molecule (O1W), the nitrogen atom which are from the triazole ring of the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from the triazole ring the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from the triazole roxygen atoms which are from the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from the triazole roxygen atoms which are from the DMA molecule (O9) as well as three carboxylic oxygen atoms which are from three TZMB²⁻ ligands (O5, O3, O2A). In addition to this, the bond lengths between Co



Fig. 1 (a) View of asymmetry unit of 1. (b) The $TZMB^{2-}$ ligand coordination mode. (c) The 1's 3D framework. (d) The 2-nodal (3,5) connection network of 1.



Fig. 2 (a) View for the asymmetry unit of **2**. (b) The $TZMB^{2-}$ ligands coordination pattern. (c dimensional channels. (d) The 3-nodal (3,4,7) connection net of **2**.

and O ranges from 2.067(4) Å to 2.264(0) Å. Similarly, bond lengths between Co and N are in the range of 2.217(0 2.252(5) Å. During 2's self-assembly process, the H_2TZME ligands are completely deprotonated in both different ordination patterns, namely, $(\kappa^1 - \kappa^1) - (\kappa^1 - \kappa^1) - \kappa^1 - \mu^4$ and $(\kappa^1 - \kappa^1) - \kappa^1 - \mu^5$ (Fig. 2b). According to Fig. 2c, the Co1 at)-(κ¹-Co2 ions are linked to the TZMB²⁻ light ds called a groups, thus constructing the one-dimensioner $\{Co_2(COe_k)_q chains, in which the closest Co2...Co1A as uses are 4.0.01(1) Å and 5.0492(1) Å, forming a three-dimensional frame connected by the TZMB²⁻ ligande. View distance is an experimental distance of the transfer of the tr$ by the TZMB^{2–} ligands. Via calizing PLATe 1. the **2**'s cavity volume is 1969.9 Å³ in 8841.5 Å³ per unit cell volume acquired, and the porosity is above 22.3%, 7 arough topology, the 7-c, 4c as well as 3-c nodes are the opresentation of $\{Co_2(COO)_4\}_n$ SBUs and two bint of T_{λ} (B^{2-}) in ads severally, but the entire framey it of 2 can rewed to be a threedimensional detwork f 3-nodal (3,4,7) connection and the $(+ \cdot 0) + (- \cdot 8^6)$ (Fig. 2d). dot symbol 1. 1².6

researches of powder X-ray diffraction In Fig. 3a, (PXRD) have been performed on those compounds so that products' phase purity can be checked. The positions of the peak obtained by experiment is highly consistent with that obtained by simulation, which shows that the crystal structures exhibits that it's really the bulk crystal products. The intensity distinctions might be due to crystal samples preferred orientation. TGA was operated for testing the thermal stabilities of CPs 1-2. In terms of complex 1, the TGA curve shows that there is a weight loss of 5.37% from 373 to 421 K, which could be due to the removal of one lattice and one coordinated water molecules (calculated 5.55%) Afterwards, when the temperature rises to 573 K, the collapse of framework will occur and the decomposition of the ligand could be observed. At the

rdination patern. (c) A 3D framework of **1** exhibiting the one-

emperature of 973 K, the weight loss still occurs, indicating product CoO would be found in a much higher temperature. In terms of 2, one coordinated water molecule between 298 K and 383 K results in a weight loss of 1.84% (calculated 1.91%). One coordinated DMA molecule and one lattice between 398 K and 513 K results in a weight loss of 18.67% (calculated 18.41%). When the temperature rises to 683 K, the framework will start to collapse. The optical properties of H_2L and 4-bipb as well as compounds 1–2 were carried out with solid-state UV-vis spectra at room temperature, and the results are displayed in Fig. 3c, d. As shown in Fig. 3a, the main absorption peaks at 286 nm (H_2L) and 296 nm (4-bipb), which can be ascribed to $\pi \to \pi^*$ and $n \rightarrow \pi^*$ transitions of the ligands, respectively. The energy bands at 520-540 nm (for 1) and 580-600 nm (for 2) are assigned as *d*-*d* spin-allowed transition of the $Co^{2+}(d^7)$ ions. The lower energy bands at 206, 328 nm for 1, 207, 313 nm for 2 are considered as intraligand transitions.

3.2. Magnetic properties

When the temperature range is between 2 K and 300 K by applying a 1000 Oe magnetic field, we explored the variable-temperature magnetic properties of 1 and 2. Figs. 4 and 5 exhibits the relationship curves of the χ_M and $\chi_M T$ versus. As shown in Fig. 4a, due to the non-quenching orbital momentum contribution of the center Co(II) ions in 1, the experiment value of $\chi_M T$ at 300 K is 8.2 cm³·K·mol⁻¹, greater than the expected high spin-only value (7.5 cm³·K·mol⁻¹) of four magnetically alone Co(II) ions (S = 3/2, g = 2) [20]. The dominant antiferromagnetic behavior of 1 was revealed by the results of the $\chi_M T$ value decreasing continuously to the least value



Fig 3 (a) The PXRD modes of 1 and 2. (b) The TGA curves of 1 and (curves of 1 and (curves of 0) and (curves of 1) and (c



Fig. 4 (a) The first of χ_M blots for twhen the temperature is between 2 K and 300 K by applying a 1000 Oe magnetic field, the red line represent the jest fit $\chi_M T$ as a real to the Eq. (1); (b) $1/\chi_M$ plot for 1 and fit by the Curie-Weiss law.

2.09 cm³·K·m⁴ at 2 K [21]. Beyond that, the reciprocal magnetic susceptible $(1/\chi_M)$ above 25 K conforms to the Curie-Weiss law, i.e. $\chi_M = C/(T-\theta)$ (Fig. 4b), where the negative Weiss constant θ is equal to -32.9 K and the Curie constant C is equal to 9.17 cm³·mol⁻¹·K [22]. Also the magnetic susceptibility data of 1 were analyzed via the following Hamiltonian equation:

$$H = g\mu_B BS + D\left[S_z^2 - \frac{S(S+1)}{3}\right] + E\left(S_x^2 - S_y^2\right)$$
(1)

where formula is the isotropic exchange interaction between two spinning doublets ($\hat{S}_1 = \hat{S}_2 = 3/2$). The best-fit (red line in Fig. 5A) give $g_x = g_y = 2.43$, $g_z = 2.03$, E = 0.03 cm⁻¹, D = 25.35 cm⁻¹. The B is Boltzmann constant. As for **2**, the maximum value of $\chi_M T$ for **2** is 16.85 cm³ K mol⁻¹ at 300 K, greater than the anticipative high spin-only value (15 cm³·K·mol⁻¹) of eight magnetically alone Co(II) ions (S = 3/2, g = 2) (Fig. 5a). And the $\chi_M T$ reach to 5.31 cm³·K·mol⁻¹ at a temperature of 2 K. Also the reciprocal magnetic susceptibility (1/ χ_M) above 25 K are fit to the Curie-Weiss law, i.e. $\chi_M = C/(T-\theta)$ (Fig. 5b), where the negative Weiss constant θ is equal to -24.65 K and the Curie constant C is equal to 18.29 cm³·mol⁻¹. The negative θ also proves the antiferromagnetic interaction behavior in **2**. Also the magnetic susceptibility data of **2** were analyzed via the following Hamiltonian equation:

$$H = -2JS_1S_2 \tag{2}$$



Fig. 5 (a) The $\chi_{\rm M}$ and $\chi_{\rm M}$ T plots for **2** when the temperature is between 2 K and 300 K by applying a 1000 f magnetic old, the red line represent the best fit of $\chi_{\rm M}$ T according to the Eq. (2); (b) $1/\chi_{\rm M}$ plot for **2** and fit by the Curie-Weiss law

where the formula is the isotropic exchange interaction between two spinning doublets ($\hat{S}_1 = \hat{S}_2 = 3/2$). The best-fit (red line in Fig. 5A) give J = -1.49 cm⁻¹, g = 2.46, D = 15.76 cm⁻¹. The negative J value also suggests antiferromagnetic interaction between the center Co(II) ions.

3.3. Inhibition of the compound on levels of the IL-6 and IL-18 released by inner ear endothelium

After the synthesis of compounds 1 and 2, their biological activity was evaluated firstly by measuring the IL-6 and IL-18 level in the lymphatic fluid of inner ear. As the result showed in Fig. 6, we can see that IL-6 and IL-18 levels of the lymphatic fluid of inner ear of the model group were greatly higher than those of control group. While, after treated with compound 1, the IL-6 and IL-18 levels in the lymphatic fluid of inner ear was significantly reduced, but compound 2 has little influence on the release of inflamm pory prove In addition to this, the gands of the key empounds both showed no inhibitory effect on the IL-6 and IL-18 levels.

3.4. Obviously reduction effect of the compound on the relative expression let a 5 the ROS have genes

matory response after tissue ischemia is a dynamic The inf ss of the interaction of various cells in the ischemic zone. pro r CIRI, the amaged cells would release large amounts of A R ease of ROS will further aggravate the dam-Excessive endothelial cells. Thus, the levels of ROS f inner ea age pression were measured in this study via real related RT-PCR. The results in Fig. 7 showed that the ROS nes expression level was relatively high in the model group than the control group. After treatment of the compound 1, the relative expression levels of ROS-related genes were significantly decreased, which is much stronger than the activity of compound 2. In addition to this, the ligands of



Fig. 6 Compound significantly reduced the levels of the IL-6 and IL-18 released into the lymphatic fluid of inner ear. The CIRI animal model was established, and then compounds **1** and **2** were given for treatment at 5 mg/kg. Then the lymphatic fluid of inner ear was gathered, the IL-6 and IL-18 levels was determined via ELISA detection kit.



Fig. 7 Compound significantly reduce the relative expression levels of the ROS related genes. The CIR mimal more was established, and then compounds 1 and 2 were given for treatment at 5 mg/kg. The inner ear endothelium was isoned and real the RT-PCR was conducted for the ROS related genes evaluation.

the new compound both showed no inhibitory effect on the relative expression levels of ROS-related genes.

4. Conclusion

To sum up, under the solvothermal reaction conditions, two coordination polymers have been synthesized via utilizing Ytype N-heterocyclic carboxylic acid 4,4'-(1H-1,2,4-triazol-1-y 1)methylene-bis(benzoic acid) with or without using the pyridine ancillary linker 1 1,4-bis(pyrid-4-yl)benzene (4-bipb). Through IR spectroscopy, single crystal X-ray diffra thermogravimetric (TG) analysis, the elemental analysi as well as single-crystal X-ray diffraction, both of the synthesized polymers have been absolutely terize According to the magnetic researches, the Aiferro agnetic coupling between contiguous metal ions st in c apounds 1 and 2. The data of the ELISA assay low th compos inhibith the levels of 1 showed a much prominent effect IL-6 and IL-18 than compound In addition this, the results of real time RT-PCR and exhibited compound 1 was much stronger than compand 2 on Nucing the relative expression of ROS relevant genes. In the expression we concluded that compound 1 was aperior compound 2 in CIRI treatment by reducing the vels IL-6 and IL-18 released into the lymphatic fluid of in. ear and mibiting the expression of ROS relat gen

5. Data av Jabilit

The data used to populate findings of this study are included within the article.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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