**A new Zn(II)-coordination polymer based on m-terphenyl pentacarboxylic acid ligand for photocatalytic methylene blue degradation and protective effect against Alzheimer's disease by reducing the inflammatory response and oxidative stress in the nerve cells**

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**Abstract**

In this work, a novel two-dimensional coordination polymer was prepared via reaction of 4,4′-dipyridyl (4,4′-bipy) with Zn(NO3)2·6H2O and m-terphenyl pentacarboxylic acid (H5L) within water and DMA mixed solvent, and its chemical formula is [Zn2(HL)(4,4′-bipy)(H2O)](DMA) (**1**). Due to its good framework stability in water, complex **1** was studied as a catalyst for photocatalytic degradation of methylene blue (MB) in water under the ultraviolet light. Both of the remarkable efficiency and good catalytic stability could be achieved in the complex **1**. Furthermore, to evaluate the treatment activity of the compound on the Alzheimer's disease (AD), AD mice model was established and treated with the compound. And then, AD mice brain tissues were weighted and the cognitive function of AD mice was determined. Then, the content of amyloid β peptides (Aβ) in the hippocampus was measured with western blot; the inflammatory cytokines TNF-α along with IL-1β within CSF was detected via ELISA detection kit; oxidative stress level within the cells of nerve was determined via ROS test kit. CCK-8 assay was performed to detect the toxicity of the compound on normal human cells.

**Keywords**: Coordination polymer, Zn(II)-framework, methylene blue degradation, Alzheimer's disease

**Introduction**

Alzheimer's disease (AD) is an age-related disease of neurodegenerative. The chiefly clinical characteristics of Alzheimer's disease include progressive memory loss, cognitive dysfunction, behavioral disorders, and decreased daily living ability [1]. The main pathological features of Alzheimer's disease are amyloid β peptides (Aβ) accumulation within hippocampus along with the generation of the senile plaques (SP); tau protein hyperphosphorylation within the cells of brain nerve and the generation of the nerve fiber tangles (NFTs) in the nerve cells; the decrease of cerebral cortical nerve cells, as well as the changes of neocortex and cerebral blood vessels [2, 3]. Up to now, all drugs used for AD treatment could only improve the symptoms of AD to a certain extent, such as regulating the excitability of neurons and slowing the cognitive impairment of AD patients, but which could not change the pathogenesis of AD patients and cure AD completely [4-6]. Thus, development new candidates with multifunction and multifunction was needed in the present.

Coordination polymers (CPs) are novel kinds of crystal materials which are self-assembly with metal clusters/ions as the vertices along with organic ligands as the connectors [7-9]. Generally speaking, CPs have a wide impressive range in gas separation and storage, different catalysis, fluorescence sensors and the delivery of drug, immobilized metal affinity chromatography (IMAC) as well as proton conductivity because of their diversity in structure, regulable pore sizes and skeletons, and high thermal and chemical stability [10-16]. The versatility chiefly comes from organic ligands (O- and N-donor ligands), which can adjust CPs' functional performances along with coordination networks. Aromatic carboxylic acids, as the representative O-donor ligands were widely used as the cornerstone of building CPs according to their deproton degree and various coordination patterns [17-20]. Alternative rigid bis(imidazole) ligands facilitate the bridging of metal centers with different conformations through the bending of main chains along with rotation of coordination centers around the single bonds [21]. In recent years, the environmental pollution caused by heavy metal ions along with organic dyes has greatly affected human health and peripheral ecosystems. As a heterogeneous photocatalyst, CPs were extensively used in the degradation of different organic pollutants in wastewater because of their low cost, good stability as well as high photocatalytic activity. However, many coordination polymers are not water stable or loss their framework integrity and catalytic activity after the dye degradation processes [22, 23]. The literature results have revealed that the mixed-ligand approach is a good choice for building the coordination polymers with considerable framework robustness toward water [24]. In this work, a novel two-dimensional coordination polymer was triumphantly prepared via 4,4′-dipyridyl (4,4′-bipy) reacts with Zn(NO3)2·6H2O, m-terphenyl pentacarboxylic acid (H5L) within water and DMA mixed solvent, and its chemical formula is [Zn2(HL)(4,4′-bipy)(H2O)](DMA) (**1**). Due to its good framework stability in water, complex **1** was studied as a catalyst for photocatalytic degradation of methylene blue (MB) within solution of aqueous under the ultraviolet light. Both of the remarkable efficiency and good catalytic stability could be achieved in the complex **1**. Within this biological study, protective function of the compound on AD treatment was evaluated. After establishing AD mice model, compound was injected for treatment, brain weight results and the cognitive function of mice indicated that compound could obviously raise AD mice brain weight and improve the cognitive function of AD mice. Next, the western blot data of the Aβ content in the hippocampus suggested the protective effect of the compound by reducing Aβaccumulation. Furthermore, the ELISA assay of the inflammatory cytokines exhibited that compound could decrease the inflammatory cytokines level of TNF-α and IL-1β within the cerebrospinal fluid and ease the inflammatory response in the body. In addition to this, the ROS detection results showed the compound also has the ability in reducing the oxidative stress level in the nerve cells. Finally, CCK-8 assay also confirmed that the compound has no toxicity on normal human cells.

**Experimental**

**Chemicals and measurements**

We bought the raw solvents, materials along with reagents from market and utilized them with no deep purification. With the Nicolet Avatar 360 FT-IR spectrophotometer we determined FT-IR spectra. The heat analysis equipment of Q50 TGA (TA) was utilized for the analysis of thermogravimetry within nitrogen flow and the heating rate was 5℃·min−1. On the MiniFlex (Cu Kα, λ = 1.5418 Å) we determined bulk samples powder X-ray diffraction (PXRD) at the room temperature. The UV-Vis absorption spectrum at room temperature were measured with a Hitachi 3310 UV-vis spectrophotometer.

**Preparation and characterization for [Zn2(HL)(4,4′-bipy)(H2O)](DMA) (1)**

We mixed Zn(NO3)2·6H2O of 0.1 mmol and 30 mg, H5L which is 9 mg and 0.02 mmol, 4,4′-bipy of 6 mg and 0.02 mmol as well as HBF4 which is 30 L and 37% in aq to form a mixture, and added it into deionized 1 ml water and 6 mL DMA. Then we stirred the mixture for approximately ten minutes and sealed it into a stainless steel container lined with Teflon of 25 mL, after that heated it for seventy-two hours at 120℃, and then cooled it to the ambient temperature. After washing by using water along with ethanol for many times, we acquired and collected colorless crystals, and the yield was 43% on the basis of H5L. Anal. Calcd for **1** (C37H29N3O12Zn2): C, 53.01; H, 3.49; N, 5.01%; Found for **1**: C, 53.23; H, 3.77; N, 5.24%.

Applying the diffractometer of Oxford Xcalibur E we acquired compound **1**'s X-ray data. Using the software of CrysAlisPro at the aim of analyzing strength data and then convert it into the files of HKL. According to direct method, complex **1**'s starting structure pattern was established by the program of SHELXS, and modified via the program of SHELXL-2014 according to least square method. Complex **1**'s entire non-H atom was mixed with the anisotropic parameter. All the H-atoms on the benzene rings are fixed using the HFIX command and the H atoms on water and the undeprotonated carboxylate group are assigned according the residual electron density peaks around the O atoms. Table 1 describes compound **1**'s the crystal parameters after recombination along with information of numerical value.

Table 1 Complex **1**'scrystallographic parameters along with refinement details.

|  |  |
| --- | --- |
| Empirical formula | C33H20N2O11Zn2 |
| Formula weight | 751.25 |
| Temperature/K | 293.0 |
| Crystal system | triclinic |
| Space group | P-1 |
| a/Å | 10.963(2) |
| b/Å | 13.137(3) |
| c/Å | 13.577(3) |
| α/° | 69.972(8) |
| β/° | 74.146(6) |
| γ/° | 76.533(12) |
| Volume/Å3 | 1746.1(7) |
| Z | 2 |
| ρcalcg/cm3 | 1.429 |
| Data/restraints/parameters | 6161/0/435 |
| Goodness-of-fit on F2 | 1.068 |
| Final R indexes [I>=2σ (I)] | R1 = 0.0531, ωR2 = 0.1596 |
| Final R indexes [all data] | R1 = 0.0596, ωR2 = 0.1651 |
| Largest diff. peak/hole / e Å-3 | 0.57/-0.69 |
| CCDC | 1969213 |

**Animal model construction**

The BALB/c mice (6-8 weeks) with the weight of 18-22g used in this experiment were acquired from Model Animal Research Center of Nanjing University (Nanjing, China). The mice were exposed to 45% humidity and 20–25℃ temperature condition with 12 h light or dark cycle before experiment. All the conductions in this research were approved via Ethics Committee of the Affiliated Hospital of Nanjing University (Nanjing, China). Within the research, we separated mice into five distinct groups, the control group (shame operation + PBS treatment), model group (operation+ PBS treatment), low dose treatment group (operation+ 1mg/kg compound treatment), medium dose treatment group (operation+5mg/kg compound treatment) and high dose treatment group (operation+10mg/kg compound treatment). Colchicine was injected into the hippocampus of the model and treatment group mice, the PBS was injected into the control group mice [25]. Then, the different concentration of the compound or PBS was used for the AD treatment. The weight of the brain was measured after treatment.

**Cognitive function evaluation**

After treatment with various doses of the compound, under guidance of the instruction manual with some modifications, the AD mice cognitive function was evaluated with open field test [26, 27]. In short, all the mice of different groups were placed in a wooden curtain box of 100cm×100cm×40cm (length×width×height). The bottom of the box is divided into 25 squares (20cm×20cm). The inner side wall of the box is black, and the side wall is called the outer circumference. The camera was placed in the center of the market box and connected to the computer to record the cognitive function of mice. After received with PBS or compound treatment, the AD mice were placed in the central grid, and the activity of the mice within 5 minutes was observed. The residence time (ie, latency) of the mice in the central grid was recorded.

**Aβ content measurement**

After the construction of the AD mice model and compound therapy, the Aβ accumulation level within the hippocampus was measured with western blot with the guidance of manufacturer [28]. In brief, AD mice model was established and treated with the compound at the concentration of 1, 5 and 10mg/kg. the compound was used for treatment continuously for one month. At the end of the treatment, the hippocampus tissue of the AD mice from different groups were collected and the total protein in the hippocampus tissue was extracted with Total Protein Extraction kit added with RIPA buffer. The overall protein concentration of the whole samples was measured by BCA Protein Assay Kit. Then, separating samples via SDS-PAGE gel electrophoresis and transferred to 0.22 mm polyvinylidene fluoride (PVDF) membrane by electrophoresis. After the incubation with appropriate secondary antibody along with primary antibody combined with the horseradish peroxidase, the images of protein were captured.

**ELISA assay**

The inflammatory cytokines level of TNF-α and IL-1β within the cerebrospinal fluid of AD mice after compound treatment was measured with ELISA detection kit. This experiment was performed in accordance with the protocols with a little modification [29]. In short, the mice were divided into 5 different groups as described above. Then, 3 μL of Colchicine was injected into the hippocampus of the model group and compound was given for treatment. After that, the cerebrospinal fluid was collected and the content of IL-1β and TNF-α was measured with ELISA detection kit. This experiment was carried out for three times and the results were presented as mean±SD.

**ROS detection**

Determination of accumulation of active oxygen was performed by using active oxygen test kit within the brain of AD mice after 1, 5 and 10 mg/kg compound treatment. This preformation was conducted according to the protocols previous described [30]. Briefly, the 3 μL of Colchicine was injected into the hippocampus of the model group and compound treatment group mice to induce the AD mice model. Then, different dosage of the compound was given for mice treatment. The content of the ROS accumulated in the brain was measured with ROS detection kit in flow cytometry.

**CCK-8 assay**

In this experiment, the toxicity of the synthetic MOF was evaluated wit Cell Counting Kit-8 assay (Dojindo, Japan) on HIEC cells. This preformation was carried out according to the instruction with a little modification. in brief, the HIEC cells in the logarithmic growth phase were harvested and were planted in 96-well plates at the destiny of 1×104/well. Then, the cells were cultured in an incubator at the condition of 37℃, 5% humidified CO2 to 70-80% confluence. After that, the cells were treated with MOF (1, 2, 4, 8, 10, 20, 40, 80 μM) for 48 h, the same volume of PBS was added as the negative control. After treatment, the cells were and the cells were washed with pre-clod PBS, and the 100 μL culture medium containing 10 μL CCK‑8 (Sigma) reagent was added into each well for 4 h incubation in the dark. Finally, the absorbances of all samples were measured at a wavelength of 450 nm. This experiment weas repeated at least three times.

**Results and discussion**

**Crystal structure of complex 1**

The targeted complex **1** was produced via 4,4′-bipy ligand, H5L and Zn(NO3)2·6H2O solvothermal reaction within water and DMA mixed solvent, and its formula was [Zn2(HL)(4,4′-bipy)(H2O)](DMA) on the basis of the data of thermogravimetric analysis, analysis of elemental, as well as X-ray of single crystal diffraction. It need to noted that H5L ligand are neither solubled in water nor in solution of EtOH, so we used the DMA as the key solvents in the synthesis of **1**. According to crystal data which collected under the ambient temperature, the results of structural solution along with refinement reveal that complex **1** crystallizes in the triclinic space group P-1 and reflects the two-dimensional layered network. The asymmetric unit of **1** consists of two Zn(II) ions which have distinct coordination configuration, a full HL4- anion, a coordinated 4,4′-bpy ligand as well as a coordination water molecule (Fig 1a). Zn1 is a tetrahedral coordination geometry composed of three oxygen atoms (O8#1, O3 and O1) from a HL4- carboxyl group along with a nitrogen atom from ligand of 4,4′-bipy. Zn2 has the distorted octahedral configuration. The six-ligands are coordinated via four oxygen atoms (O4 and O11, O5#3 and O6#3) from a HL4- carboxylic acid group, an oxygen atom from the coordination water molecule as well as a nitrogen atom from ligand of 4,4′-bpy. The Zn(II)-O bond distances are in the region of 1.901(2) to 2.175(3) Å, and the Zn(II)-N bond lengths are with the scope of 2.002(3) to 2.056(3) Å, which are comparable with those found in the Zn(II)-based coordination polymers constructed from the carboxylate and pyridinyl co-ligands [31-33]. Within **1**, a HL4- carboxyl group is protonated without coordination. The other four HL4- ligand carboxylic acid groups link four ions of Zn2+ via a μ1-η1:η0, a μ1-η1:η1 as well as two μ2-η1:η1 coordination patterns. The distinctive HL4- ligand links Zn1, and neighbouring Zn2 are connected via two carboxyl groups, forming the [Zn2(COO)2]2+ binuclear unit, and the distance of Zn1···Zn2 was 4.26 Å (Fig 1b). The binuclear units which has the 4,4′-bipy ligands along with main ligand as ligands generated a 2D layered framework (Fig 1c). The layered framework extends via the intermolecular hydrogen bonds O11-H11···O9 and O5-H5···O10, the length of bond is 1.863 and 2.636(3) Å, ultimately the 3D supramolecular structure was formed (Fig 1d and Fig 1e). In topology, the HL4- connector could be simplified as the three-linked node, and the binuclear unit of [Zn2(COO)2]2+ could be simplified as the six-linked node. Thus, compound **1** could be considered as the (3,6)-linked kgd net, and the symbol of Schläfli was (43)2(46.66.83) topology. The solvent accessible volume for **1** is calculated to be 875.4 Å3, corresponding to 50.1% of the crystal volume (1746 Å3).

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**Fig. 1** (a) Zn(II) ions coordination surroundings view. (b) HL4- ligand coordinated pattern view. (c) **1**'s two-dimensional layered network view along the a axis**.** (d) H-bond interactions between the adjacent layers. (e) The 3D H-bond framework of **1**.

**PXRD and TGA analysis**

The analysis of powder X-ray diffraction was carried out in order to promoted identify prepared **1** composition completeness. According to Fig. 2a, most diffraction crest value places of synthesized **1** wereaccording to the diffraction data, it is in good agreement with the simulated single crystal figure, indicating that **1** has high crystallinity and high purity phase. Considering the following photocatalytic experiments in water, it is necessary to study the stability of complex **1** in the water solution. The PXRD patterns of the as-prepared **1** crystal samples were collected after soaking within the water for 24 hours. The results revealed that the PXRD patterns of the treated **1** crystal samples were similar to those of the newly prepared **1** crystal samples, reflecting its considerable stability in the targeted solution. **1**'s thermal stability was studied via TGA. **1**'s curve of TGA reveals the first weightlessness of 12.52% from room temperature to 166℃, corresponding to remove a coordinated water molecules along with a lattice DMA molecules (Fig 2b). After a plateau from 166 to 366℃, the second weightlessness, which is due to carboxylate groups release in the form of CO2 and decomposition of the organic ligand, took place in the temperature range of 391℃ to 454℃.



Fig. 2 (a) **1**'s pattern of PXRD. (b) **1**'s curves of TGA.

**Photocatalytic methylene blue (MB) degradation**

Methylene blue (MB) along with methyl orange (MO) are the most familiar organic dyes in textile wastewater. Thus, they are chosen as the model pollutants to assess photocatalytic effect. The experiment of control showed that the degradation of MB along with MO had no obvious change without catalyst **1** (Fig. 3a and Fig. 3b). Although adding catalyst **1** to the reaction system, MO' degradation rates was very slow, about 15.9% MO was decomposed under the irradiation of UV for seventy minutes (Fig. 3c). This means that the photocatalytic activity of **1** to MO is poor. Compared with the photodegradation of MO, the degradation of MB reveals a sharp change with **1** as a catalyst (Fig. 3d). After the irradiation of UV for seventy minutes, MB was decomposed via **1** as a catalyst about 90.8%, respectively. These results reveal that **1** has good photocatalytic activity for the degradation of MB. In addition, **1**'s photocatalytic activity for the degradation of MB is better than those of other coordination reagents based on polymer, and the photocatalytic efficiency is higher in the irradiation time of seventy minutes. After the reaction of photocatalysis, **1**'s XRD spectrum powder changed, which was consistent with that of **1** within aqueous solution. The mechanism of photocatalytic reaction may be considered as follows: with irradiation of natural light, e− within the highest occupied molecular orbital (HOMO) are excited to the lowest unoccupied molecular orbital (LUMO), thus generating the same number of h+ within the HOMO (Fig 4). The hydroxyl radicals (·OH) is formed by the deep interaction between positive holes and hydroxyl ions (OH−). At the same time, the electrons within LUMO can be captured via O2 within the system of photocatalytic, generating the superoxide anion radicals (·O2−). And then, ·OH was formed via the interaction between ·O2− and H2O. The molecules of MB can be mineralized into some benzene ring, even H2O and CO2 as well as other non harmful inorganic intermediates through the whole hydroxyl radicals which have strong oxidizing ability while MB's structure is collapsed.



Fig 3. The absorption spectra of UV visible for the solution of MO (a) and MB (b) without catalysts under the irradiation of UV at the distinct time intervals. The organic dye UV-Vis absorption spectra degradation in distinct time under the irradiation of UV; (c) **1** within MO; (d) **1** within MB.

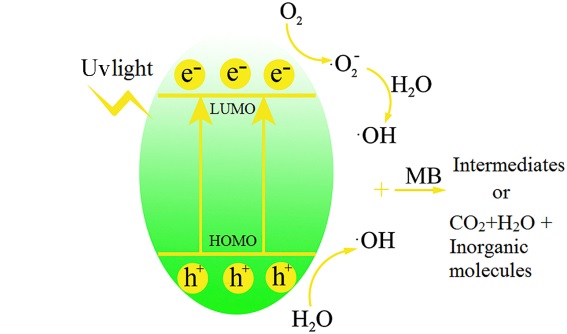


Fig. 4 Schematic diagram for MB mechanism of photocatalytic degradation.

**Compound improved the volume and weight of the brain in AD mice model**

The brain atrophy, ventricular enlargement and loss of brain weight was classical character of the Alzheimer's disease. So, in this experiment, protective function of the compound on AD was assessed via the measurement of the volume and weight of the brain in AD mice model after indicated treatment. According to the results of Fig. 5, we can see there was an obvious reduction of the volume of the brain and a loss of the brain weight in the model group compared with the group of control. While, after the compound therapy, lesion degree was significantly improved, and the protective function of the compound showed a significant dose-dependent relationship, which reflected as the relatively increased level of the brain volume and decreased loss of brain weight. All these results revealed that the compound has excellent protective effect against the AD.

Fig. 5 Improved the volume and weight of the brain in AD mice model after compound treatment. Colchicine was injected into the hippocampus of mice to induce the AD model, and the 1, 5 and 10mg/kg compound was injected for treatment. The volume and weight of the brain in AD mice model was measured and recorded. \*\*\*means *p*<0.005.

**Compound improved the cognitive function of the AD mice**

Within the former experiment, we have demonstrated that compound could increase the weight and volume of the brain in AD mice significantly in a dose-dependent manner. However, whether the compound could show excellent improvement effect on AD mice cognitive function *in vivo* was still unclear. Thus, the open field experiment was used to reflect AD mice cognitive function after the combine therapy. According to the results of Fig. 6, we got this information, the residence time of the AD mice stayed in the central grid was much longer than the control normal mice. While, after the compound treatment, the time of mice spent in the central grid was obviously reduced, and the time showed a downward trend compared with the increase of the compound.

Fig. 6 Improved the cognitive function of the AD mice after compound treatment. Colchicine was injected into the hippocampus of mice to induce the AD model, and the 1, 5 and 10mg/kg compound was injected for treatment. The open field test was performed to assess improvement activity of the compound on AD mice cognitive ability.

**Compound reduced the accumulation of Aβ 40 and Aβ 42 in the hippocampus**

The abnormal deposition of Aβ showed a significant toxic effect on neurons, and have an important influence on the pathogenesis of AD. The precursor of Aβ could be cleaved into two mainly forms, one is a protein fragment consisting of 40 amino acids, named as Aβ 40, another is consist of 42-43 amino acids, named as Aβ 42. Both of the Aβ 42 and Aβ 40 are the classical indicator of the clinical AD monitoring, which could induce the formation of the senile plaque, and have been the indicator for the clinical monitoring. So, in this experiment, the content of the Aβ 40 and Aβ 42 accumulation in the hippocampus was measured by western blot assay after compound treatment. In Fig. 7, the results of western blot revealed that the accumulation level of Aβ 42 and Aβ 40 in group of model was obviously higher than that in group of control, there was an obvious difference of the two groups (p<0.001). After compound treatment, the Aβ accumulation in the cerebrospinal fluid was obviously reduced, and this inhibitory effect as enhanced compared with the increased concentration of compound. This result suggest that the compound could reduce the accumulation of Aβ 42 along with Aβ 40 within the hippocampus and then exert protective effect in the AD treatment.



Fig. 7 Decreased accumulation of Aβ 42 along with Aβ 40 within the hippocampus after compound treatment. Colchicine was injected into the hippocampus of mice to induce the AD model, and the 1, 5 and 10mg/kg compound was injected for treatment. The level of the Aβ 40 and Aβ 42 accumulation in the hippocampus after compound treatment was measured with western blot.

**Compound reduced the level of inflammatory cytokines in the** **cerebrospinal fluid of AD mice**

There was usually an increased level of the inflammatory cytokines within AD patients' cerebrospinal fluid, such as TNF-α along with IL-1β. So, in this experiment, after compound treatment, the inflammatory cytokines level of TNF-α along with IL-1β within the cerebrospinal fluid of AD mice was measured with ELISA detection kit. According to the results of Fig. 8, there was an obviously improved level of TNF-α and IL-1β level within the cerebrospinal fluid of AD mice compared with the normal mice. But, after the compound therapy, TNF-α and IL-1β content within cerebrospinal fluid was significantly reduced in a dose related manner.

Fig. 8 Decreased inflammatory cytokines level within AD mice cerebrospinal fluid after compound treatment. Colchicine was injected into the hippocampus of mice to induce the AD model, and the 1, 5 and 10mg/kg compound was injected for treatment. Detection of TNF-α and IL-1β accumulation via ELISA test Kit within the cerebrospinal fluid after compound treatment.

**Compound suppressed** **oxidative stress level in the nerve cells**

Oxidative stress is associated with the pathogenesis of many diseases of neurodegenerative (Parkinson's disease and Alzheimer's disease). Excessive oxygen free radicals play an important role within oxidative stress. The increase of intracellular the oxidative stress is because of the unbalance of ROS production and intracellular antioxidant mechanism. The results in Fig. 9 reflected the accumulatio of ROS in nerve cells after the compound therapy, the ROS level of model group was obviously higher than that of the group of control. The compound application could significantly decreased ROS level within the nerve cells.





Fig. 9 Decreased level of ROS in the nerve cells after the combine therapy. Colchicine was injected into the hippocampus of mice to induce the AD model, and injected the compound of 1, 5 and 10mg/kg to perform treatment. The accumulation of ROS within the nerve cells after the combine therapy was determined with ROS detection kit in flow cytometry.

**MOF showed no toxicity on HIEC cells**

In the previous researches, we have confirmed the excellent treatment of the compound on AD model, and the specific mechanism was also revealed. However, whether the MOF showed toxicity on normal human cells was still unclear. Thus, the CCK-8 assay was performed to detect the influence of the compound on HIEC cells viability. As the results showed Fig. 10, after treated with serious dilutions of MOF, the cell viability of HIEC was no influenced, which indicated that MOF showed no toxicity on normal human cells, indicating that the compound has the advantage of low toxicity.



Fig. 10 Toxicity of the MOF on HIEC cells. The HIEC cells were incubated with serious dilutions of MOF, and the cell viability was evaluated with CCK-8 assay.

**Conclusion**

To sum up, we have prepared the 2D coordination polymer via reaction of 4,4′-dipyridyl (4,4′-bipy) with Zn(NO3)2·6H2O, 3,5-(di(2',5'-dicarboxylphenyl)benozoic acid (H5L) within water and DMA mixed solvent. The study of single crystal X-ray reveals that complex **1** has the binodal (3,6)-linked **kgd** network with the topology of (43)2(46.66.83). Due to its good framework stability in water, complex **1** was studied as a catalyst for photocatalytic degradation of methylene blue (MB) within solution of aqueous under the ultraviolet light, which shows high efficiency and good catalytic stability. Within this biological study, treatment function of the compound on AD mice was assessed and the specific mechanism was explored. In *vivo*, the compound obviously raise AD mice brain weight and improve the cognitive function of AD mice, and the Aβ 40 and Aβ 42 accumulation in the hippocampus was reduced after compound treatment. Furthermore, the ELISA assay exhibited that compound could decrease the inflammatory cytokines level of TNF-α and IL-1βease the inflammatory response in the body. In addition to this, the ROS results showed the compound also has the ability in reducing the oxidative stress level in the nerve cells. Finally, the CCK-8 assay showed the compound has no toxicity on normal human cells.

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