Photocatalytic Degradation of Composites with Magnesium Aluminum Hydrotalcite Derived Metal Oxides and g-C₃N₄

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Abstract
The remove of the organic pollutants in water plays an important role on the environmental protection, thus photocatalysis, as an effective method, has been attained much attention to deal with this problem. In this paper, a composite of g-C₃N₄ and Mg–Al hydrotalcite derived metal oxides was prepared by simple co-precipitation methods followed by calcination. The effective adsorption-photocatalysis synergic effect and highly efficient removal of organic pollutants from water under simulated sunlight irradiation was found in the presence of fabricated metal oxide nanocomposites. The photocatalytic degradation rate of methylene blue reached 97.3% within 1 h under visible light, and the degradation rate constant was 0.0432 min⁻¹, which is 3.6 times that of g-C₃N₄. Though characterization analysis, more active sites are exposed to absorb more organic pollutants on the mater surface in the presence of the open hierarchical structures of composite materials, and the “face to face” contact structure between 2D materials is formed to promote the separation of electrons and holes. The photocatalytic degradation was stable in the recycling process of the catalyst. In addition, the photocatalytic degradation mechanism of the catalyst was explained by free radical scavenging experiment. The material provides an effective method for removing organic pollutants in water, and has broad application prospects.

Keywords Photocatalytic degradation · g-C₃N₄ · 2D material · Mg–Al hydrotalcite derived metal oxides

1 Introduction
With the massive consumption of global fossil energy and the rapid development of industrialized society, the water pollution dominated by industrial wastewater has become an urgent problem to be solved all over the world [1]. However, photocatalysis is considered as one of the promising methods for environmental remediation and energy saving, which is attributed to the continuous formation of highly active oxidation free radicals to effectively degrade organic pollutants in sewage [2, 3]. Semiconductors, as photocatalysts, are applied in the degradation of pollutants. However, some traditional photocatalytic semiconductors with the disadvantages of low light response range and fast photogenerated electron hole recombination rate, cause limited photocatalytic performance in the process of actual application [4, 5]. Therefore, the key of photocatalytic technology is to find excellent semiconductor materials and effective methods to modify photocatalytic activity of semiconductor materials.

As a polymer semiconductor material with low cost, non-toxicity and stable structure, g-C₃N₄ has a band gap of about 2.7 eV and can absorb part of visible light, making it a potential material widely used in the field of environmental photocatalysis [6, 7]. g-C₃N₄ is composed of two abundant elements, carbon and nitrogen, and is easy to be synthesized [8]. At present, the preparation methods of g-C₃N₄ include high-temperature and high-pressure [9], deposition [10, 11], solvothermal method [12, 13], thermal polymerization [14, 15], etc. But there are some challenges of small specific surface area, low conductivity and easy recombination of electron holes. Therefore, it is necessary to modify g-C₃N₄ to improve the photocatalytic performance [16]. Compared to the common modification methods of element doping [17, 18], structural regulation [19, 20], the construction of composite materials is a simple
and effective modification method to match energy levels with other semiconductor materials [21, 22].

Layered bimetallic hydroxides (LDH) can be used as a potential composite material to enhance the photocatalytic performance due to the characteristics of anion exchange between layers, adjustable internal structure, large specific surface area and strong regeneration ability. The metal cations were dispersed between layers on the 2D semiconductor with hydrotalcite structure as the charge separation center to effectively improve the catalytic performance, so LDH has been widely used in wastewater treatment as adsorbents and photocatalysts [23]. The mixed metal oxide formed after calcination of LDH is a derivative of LDH, with "memory effect" and the layered structure is restored by the effective remove of the anions in the solution. Moreover, the surface properties of materials are significantly improved in the presence of surfactants and polymer materials [24, 25]. Furthermore, catalytic active sites are provided by the addition of 2D materials due to their high aspect ratio and wide exposed edges. The "face to face" contact between the interfaces was achieved by the combination of the two 2D structure of the semiconductor materials, and the charge transfer rate is faster, to enhance the photocatalytic reaction and provide an idea for the construction of excellent photocatalytic materials [26].

Based on the above theoretical basis, the efficient photocatalysts of the photocatalytic reaction can be prepared by the combination of g-C$_3$N$_4$ with Mg–Al hydrotalcite derived metal oxides. The existing preparation methods include electrostatic self-assembly [27], solvothermal method [28], in-situ coprecipitation [29], etc. For the electrostatic self-assembly method, the assembly was driven by the electrostatic interaction between materials [30], but the assembly process was difficult to control, and mainly affected by the surface charge and roughness of materials. Solvothermal method was beneficial to crystallization of the product under high pressure, and the dispersion of the reaction precursor was improved with some organic solvents, thus promoting the construction of composite structure. However, there were some problems such as harsh preparation conditions and difficult environmental protection treatment of solvent [31]. Co-precipitation was a method in which an alkaline solution could be added to a mixed solution of metal cations required for the main body layer and then the resulting suspension could be aged to obtain the desired material [32]. The basic strategy for constructing LDH-g-C$_3$N$_4$ by co-precipitation method was to adsorb metal cations on g-C$_3$N$_4$ nanosheets by physical adsorption, and then precipitate in situ [33]. Due to its simple operation, low cost, controllable reaction conditions, short synthesis time, and uniform product composition, this method had become an important method for the synthesis of hydrotalcite composite materials.

To improve the photocatalytic reaction, we first prepared the MgAl-LDH and g-C$_3$N$_4$ composite material by the co-precipitation method, and then calcined it into MgAl-CLDH-g-C$_3$N$_4$ with excellent visible light response. Compared with a single semiconductor, the composite material with a unique high-exposure edge hierarchical structure, was used to degrade methylene blue solution, which can efficiently degrade methylene blue in water in a short time under simulated sunlight. Various characterization techniques were used to analyze these hierarchical structures and photocatalytic activity in depth. Based on the results of free radical scavenging experiments, the mechanism of photocatalytic degradation was inferred. The successful synthesis of the composite material provided an effective strategy for the reasonable construction of a new type of photocatalyst, and had potential application prospects in the field of environmental pollutant degradation.

2 Experimental

2.1 Materials

Melamine (of 98.5%), anhydrous sodium carbonate (of 99.8%), methylene blue (of 98.5%), isopropanol (of 99.7%), triethanolamine (of 99.0%) and magnesium nitrate hexahydrate (of 99.0%) were purchased from Chengdu Kelon Chemical Co., LTD. Sodium hydroxide (of 97.0%) and aluminum nitrate nonahydrate (of 99.0%) were purchased from Aladdin Chemical Reagent Co., LTD. P-benzoquinone (of 97.0%) was purchased from Shanghai Macklin Biochemical Co., LTD. Deionized water was used for all synthesis and treatment processes under ambient conditions.

2.2 Preparation of g-C$_3$N$_4$

As one of the raw materials for composite materials, pure g-C$_3$N$_4$ monomer was synthesized by thermal condensation in atmospheric atmosphere. The specific steps are as follows: 10 g of melamine was put into a crucible with a lid, heated to 550 °C at 10 °C/min in muffle furnace, and calcined for 2 h. After it was cooled to room temperature, the yellow product was collected and ground into a powder.

2.3 Preparation of MgAl-CLDH-g-C$_3$N$_4$

The composite of g-C$_3$N$_4$ and Mg–Al hydrotalcite derived metal oxides was prepared by simple coprecipitation and calcination methods. 0.5 g g-C$_3$N$_4$ was immersed in 0.2 mol/L Na$_2$CO$_3$ solution of 50 mL to obtain the mixed solution in a reaction beaker and stirred at 65 °C. Mg(NO$_3$)$_2$·6H$_2$O (of 10 mmol) and Al(NO$_3$)$_3$·9H$_2$O (of 5 mmol) were dissolved in 100 mL deionized water as salt solution and loaded in
the acid type burette. 1 mol/L NaOH solution was added to the alkaline type burette. Next, the salt solution and alkaline solution were dropped into the beaker under magnetic stirring at the same time, and pH value of the solution was controlled in 10.5 in the process. The pH value of the solution was adjusted to 11 after titration. The mixed solution was aged for 24 h at 65 °C. After aging, it was washed to PH = 7 with deionized water, then dried and ground to yellow powder to obtain MgAl-LDH-g-C$_3$N$_4$. MgAl-LDH-g-C$_3$N$_4$ powder was put into muffle furnace and calcined at 400 °C for 1 h to attain MgAl-CLDH-g-C$_3$N$_4$. For comparison, MgAl-LDH and MgAl-CLDH were prepared by the above method without the addition of g-C$_3$N$_4$. The specific preparation was shown in Fig. 1.

2.4 Analysis and Testing Equipment

The morphology of the catalyst was analyzed by scanning electron microscope (Apreo 2C, Thermo Scientific Co., Ltd, the United States) and transmission electron microscope (JEOLARM200, Japan). The phase structure was measured by X-ray diffractometer (X.PERT PRO, PANalytical Corporation, Netherlands). The molecular structure of the catalyst was analyzed by infrared spectrometer (WQF520, Beijing Rayleigh Analytical Instruments Co., Ltd., China). The element qualitative and chemical state analysis of the catalyst were determined by X-ray photoelectron spectrometer (NEXSA, Thermo scientific Co., Ltd, the United States). The ultraviolet–visible absorption spectrum of the catalyst were determined by X-ray photoelectron spectrometer (NEXSA, Thermo scientific Co., Ltd, the United States). The fluorescence spectrum was analyzed by fluorescence spectrum analyzer (F-7000 DC-0506, Hitachi High-tech Co., Ltd, China). The absorbance value of methylene blue solution was determined by visible light spectrophotometer (V1800, Shimadzu Corporation, Japan). The Determination of the metal element content of the catalyst before and after photocatalytic degradation was analyzed by ICP-MS (7700, Agilent Technologies Inc., the United States).

2.5 Photocatalytic Performance Evaluation

The photocatalytic performance evaluation was carried out in a self-made photocatalytic degradation device. Methylene blue solution was used as simulated wastewater. The superiority of the photocatalyst was investigated by the photodegradation of methylene blue solution. The amount of 25 mg of the prepared sample was thoroughly distributed in a methylene blue solution (50 mL, 10 mg/L). First, the dark reaction was carried out. The suspension was physically stirred by a magnetometer for 0.5 h in the absence of light to reach an adsorption/desorption equilibrium state. Then 5 mL of the solution was taken out at intervals of 15 min after the light source was turned on. At last, the wavelength of methylene blue solution was tested by V1800 visible spectrophotometer. After the test, the water was poured back to the beaker. The subsequent operation was the same as above. The degradation rate of methylene blue solution was calculated by formula (1) and the pseudo first-order kinetic constant was calculated by formula (2).

\[ \eta = \frac{A_0 - A_t}{A_0} \times 100\% \]  

(1)

where \( \eta \) represents the degradation rate of methylene blue solution (%); \( A_0 \) is the initial absorbance value of methylene blue solution; \( A_t \) represents the light absorption value at time \( t \).

\[ \ln(C_0/C_t) = kt \]  

(2)

where \( k \) is the first-order kinetic constant \( (\text{min}^{-1}) \); \( C_0 \) represents the concentration of methylene blue solution at the initial time (mg/L); \( C_t \) represents the concentration of t
methylene blue solution (mg/L); t is the illumination time (min).

3 Results and Discussion

3.1 Characterization Methods

3.1.1 SEM

The g-C₃N₄ nanosheet with curled two-dimensional layered structure was observed, as shown in Fig. 2a. The sheet structure of MgAl-LDH was stood on the surface of g-C₃N₄ nanosheet and was interlaced with each other due to more exposed unsaturated sites at the edge of LDH to strengthen edge-to-surface stacking, as depicted in Fig. 2b. The MgAlCLDH-g-C₃N₄ structure was formed after calcination was flat and flake, as shown in Fig. 2c. The catalyst was irregular shape and more compact, compared with before calcination. The “face to face” contact between 2D materials was promoted to provide the basis for the improvement of the charge transfer rate in the photocatalysis of the catalyst. Moreover, the corresponding energy dispersive spectra of MgAl-CLDH-g-C₃N₄ clearly implied that the elements of Mg, Al, C, N and O were contained in the sample as shown in Fig. 2d. The conductivity was increased due to the Au element of the Au coating.

3.1.2 TEM

TEM characterization of g-C₃N₄ and composites was performed. g-C₃N₄ with thin nanosheet structure was prepared, as revealed in Fig. 3a. The thickness of MgAl-LDH-g-C₃N₄ and MgAl-LDH-g-C₃N₄ nanosheet was higher that of g-C₃N₄, and they were attached to the surface of g-C₃N₄. Composite materials of the two 2D structures were conducive to full contact with each other. The overall thickness of the calcined composite was increased and became closer due to the formation of metal oxides in it, which was consistent with SEM results, as shown in Fig. 3c. In addition, in order to further confirm the morphology of the composite, HRTEM characterization of MgAL-CLDH-g-C₃N₄ was carried out, as shown in Fig. 3d. The lattice spacing of g-C₃N₄ was 0.224 nm, corresponding to (002) crystal planes, and the lattice spacing

![Fig. 2 SEM images of three catalysts: g-C₃N₄ a, MgAl-LDH-g-C₃N₄ b, MgAl-CLDH-g-C₃N₄ c; EDS image of MgAl-CLDH-g-C₃N₄ d](image)
of MgAl-CLDH was 0.183 nm, corresponding to (200) crystal planes in metal oxides.

3.1.3 XRD

In order to study the crystal phase structure of the prepared composite system, XRD characterization was carried out. As for g-C\(_3\)N\(_4\), the diffractions peaks were recognized at 12.9° and 27.5°, and corresponded to (100) and (002) crystal planes, which come from the orderly arrangement of triazine units and the stacking peak of conjugated aromatic ring (JCPDS 87-1526). For MgAl-LDH, there were (003), (006), (222), (225), (228), (600), (603) diffraction surface. The (002) crystal plane diffraction peak of g-C\(_3\)N\(_4\) at 27.5° was also retained for MgAl-LDH-g-C\(_3\)N\(_4\) (JCPDS 51-1525) in addition to the above diffraction peaks, indicating that the two had successfully combined. All the peaks belonging to MgAl-LDH disappeared after 400 °C, indicating that the layered structure of hydrotalcite transformed into an amorphous mixed metal oxide structure after heat treatment. The (002) crystal plane diffraction peak of g-C\(_3\)N\(_4\) still existed at 27.5° after being calcined, indicating that g-C\(_3\)N\(_4\) was stable in air without any obvious oxidation (Fig. 4).
3.1.4 FTIR

In order to further prove the successful synthesis of the composites, they were characterized by infrared spectroscopy. The results were shown in Fig. 5. As for g-C3N4 and the two composites, the peak of 3274 cm\(^{-1}\) represented the tensile vibration of non-condensed -NH\(_2\), the peak of 1200-1600 cm\(^{-1}\) was mainly attributed to the tensile vibration of C-N bond in aromatic ring structure, and the absorption peak of 810 cm\(^{-1}\) belonged to the bending vibration of triazine structure. These absorption peaks showed that the basic structure of g-C3N4 had not been damaged after compositing [34]. As for MgAl-CLDH-g-C3N4, the absorption peak of 675 cm\(^{-1}\) corresponded to Mg-O group, and the absorption peak of 545 cm\(^{-1}\) was ascribed to the stretching of Al-O bond, which further proved the successful synthesis of composites [35].

3.1.5 XPS

X-ray photoelectron spectroscopy (XPS) analysis was applied to study the surface chemical state of the catalyst. As shown in Fig. 6a, the total spectrum of g-C3N4 verified the existence of C, N and O. In Fig. 6b, the peak of 284.6 eV in the C1s spectrum of g-C3N4 represented the residual carbon and organic carbon on the catalyst surface, the peak of 286.1 eV assigned to the combination of sp2 hybrid carbon and nitrogen bond in triazine ring, as well as the peak at 288.1 eV belonged to the combination of sp2 hybrid carbon and -NH\(_2\) group bond. The distinct peaks of 398.1 eV, 399.4 eV and 400.4 eV were shown in Fig. 6c, which were readily assigned to sp2 hybrid N (N=C–N), sp3 hybrid N(N-(C)\(_3\)), and -NH\(_2\) at the edge end of g-C3N4, respectively [35, 36]. The total spectrum of MgAl-CLDH-g-C3N4 was shown in Fig. 6d, which verified the existence of five elements: C, N, O, Mg and Al. Due to the low content of Mg and Al, the peaks effect was not obvious. In addition, the peaks in C1s and N1s of MgAl-CLDH-g-C3N4 moved towards higher binding energy than g-C3N4, as shown in Fig. 6e and f, which indicated that the close contact between g-C3N4 and MgAl-CLDH might lead to charge transfer and enhance the interface between them [37].

3.1.6 UV–Vis Diffuse Reflectance Spectrum

Since the before and after the composite of catalyst showed different absorbance for different wavelengths of light, the absorbance of the catalyst was investigated by UV–visible spectroscopy. As shown in Fig. 7a, the weak absorption phenomenon under ultraviolet light (below 400 nm) of MgAl-LDH and its derived metal oxide MgAl-CLDH could be observed, indicating that their photocatalytic performance was not high. The light absorption range of MgAl-LDH-g-C3N4 was basically the same as that of g-C3N4, and it had strong absorption in the ultraviolet range. However, MgAl-CLDH-g-C3N4 had stronger absorption than that of g-C3N4 in the visible range under the same ultraviolet absorption intensity. Additionally, the band gap width was calculated according to the linear extrapolation method. As shown in Fig. 7b, the band gap width of MgAl-CLDH-g-C3N4 and g-C3N4 were 2.78 eV and 2.84 eV, respectively. Therefore, the band gap width of g-C3N4 was effectively reduced and the visible light absorption range was improved by the incorporation of MgAl hydrotalcite derived metal oxides.

3.1.7 Fluorescence Spectrum

Fluorescence spectrum is usually used to characterize the electron hole recombination degree of catalyst. Generally, the stronger the fluorescence intensity, the easier the electron hole recombination and the worse the photocatalytic performance [38–40]. Therefore, the photocatalytic properties of materials were characterized by fluorescence spectra, which was displayed in Fig. 8. Among above materials, MgAl-CLDH-g-C3N4 had the lowest fluorescence intensity, indicating that its electron hole recombination was obviously inhibited and its photocatalytic degradation performance was the best. Therefore, the visible light absorption range of g-C3N4 was widened, the rate of electron hole recombination was inhibited and the photocatalytic performance was improved effectively by the recombination of g-C3N4 with MgAl hydrotalcite derived metal oxide.

![Fig. 5 FTIR spectrum of g-C3N4, MgAl-LDH, MgAl-LDH-g-C3N4, MgAl-CLDH, MgAl-CLDH-g-C3N4](image-url)
Fig. 6 XPS spectra a, C1s spectra b, N1s spectra c and XPS spectra d, C1s spectra e, N1s spectra f
3.2 Evaluation of Photocatalytic Performance

3.2.1 Evaluation of Photocatalytic Degradation

In order to evaluate the photocatalytic performance of the catalyst, 10 mg/L methylene blue solution was used as simulated wastewater. First, it was shielded from light for 30 min to maintain the adsorption–desorption balance, and then light was turned on. In the absence of catalyst, the photodegradation of methylene blue solution was not obvious, as revealed in Fig. 9a. Among the five catalysts, the adsorption properties of MgAl-LDH-g-C$_3$N$_4$ and MgAl-CLDH-g-C$_3$N$_4$ were improved compared to g-C$_3$N$_4$ under the dark condition, and the efficiency of MgAl-CLDH-g-C$_3$N$_4$ was better. More pollutants can be attached to the active site of the photocatalyst to enhance photocatalytic degradation of pollutants. After illumination for 60 min, the degradation rate of methylene blue solution with MgAl-CLDH-g-C$_3$N$_4$ reached 97.3%, and was significantly higher than that with g-C$_3$N$_4$ and MgAl-LDH-g-C$_3$N$_4$ methylene blue solution. In order to further study the photocatalytic performance of the material, a pseudo-first-order kinetic analysis was conducted, as shown in Fig. 9b. The degradation rate constants of MgAl-CLDH-g-C$_3$N$_4$ and g-C$_3$N$_4$ were 0.0432 min$^{-1}$ and 0.01214 min$^{-1}$ respectively. The degradation rate constant of the composite was 3.6 times that of g-C$_3$N$_4$, and the photocatalytic degradation rate was improved effectively.

3.2.2 Evaluation of stability performance

The stability of MgAl-CLDH-g-C$_3$N$_4$ was investigated under the same conditions of light avoidance and illumination time in the process of cycling employment, as depicted in Fig. 10. In the first four cycles, the photocatalytic performance of the composite material was not decreased significantly, and the degradation rate remained at about 90%, indicating that the catalytic performance of MgAl-CLDH-g-C$_3$N$_4$ was relatively stable and reproducibility was great. The degradation rate constant of the composite was 3.6 times that of g-C$_3$N$_4$, and the photocatalytic degradation rate was improved effectively.
bimetallic hydroxide structure, which reduces the photocatalytic performance to a certain extent. In addition, ICP-MS analysis was performed on the material before and after the reaction, as shown in Table 1. The results showed that the content of Mg and Al in MgAl-CLDH-g-C₃N₄ was not changed significantly before and after photocatalytic degradation, and the mass ratio of Mg to Al of MgAl-CLDH-g-C₃N₄ was maintained at about 2:1, which once again proved that the catalyst had good chemical stability.

### 3.3 Mechanism Analysis

In order to explore the main active substances of several materials for photocatalytic degradation of methylene blue solution, the experiments of free radical scavenging were carried out. 2-propanol (IPA), triethanolamine (TEA) and p-benzoquinone were used as scavengers of ·OH, h⁺ and ·O₂⁻ respectively. The addition of IPA and TEA had little effect on the degradation of methylene blue solution, as described in Fig. 11. When p-benzoquinone was added, the degradation efficiency of methylene blue solution was significantly reduced in the presence of several materials, and

![Fig. 9](image-url) Photocatalytic degradation performance diagram of g-C₃N₄, MgAl-LDH, MgAl-LDH-g-C₃N₄, MgAl-CLDH, MgAl-CLDH-g-C₃N₄ a and pseudo first-order kinetic diagram b

![Fig. 10](image-url) Cycle performance evaluation diagram of MgAl-CLDH-g-C₃N₄

![Fig. 11](image-url) The effect of three free radical scavengers on the photodegradation of methylene blue solution by g-C₃N₄, MgAl-LDH-g-C₃N₄ and MgAl-CLDH-g-C₃N₄

| Sample name                  | Elements of the test | Element mass score (%) |
|------------------------------|----------------------|------------------------|
| MgAl-CLDH-g-C₃N₄ before      | Mg                   | 17.2449                |
| photocatalytic degradation   | Al                   | 9.7102                 |
| MgAl-CLDH-g-C₃N₄ after       | Mg                   | 19.0272                |
| photocatalytic degradation   | Al                   | 10.4475                |

Table 1 ICP-MS analysis data of MgAl-CLDH-g-C₃N₄ before and after photocatalytic degradation
the degradation rate of MgAl-CLDH-g-C3N4 was decreased from 97.3% to 66.7% within 1 h. Therefore, it can be inferred that ·O2− is the main active component to enhance photocatalytic degradation instead of ·OH and h+.

In Fig. 12, methylene blue pollutants are attached on the surface of MgAl-CLDH-g-C3N4 through electrostatic adsorption, so that the pollutant molecules near MgAl-CLDH-g-C3N4 are highly concentrated. Therefore, the pollutant molecules on the surface of g-C3N4 are also enriched. The conduction band and valence band potentials of g-C3N4 were 1.44 eV and −1.30 eV, respectively, indicating that g-C3N4 can be excited to produce photogenerated electron hole pairs under visible light irradiation. The standard redox potential of O2 / O2− was (−0.33 eV), and more positive than the conduction band potential of g-C3N4 [41]. In addition, the successful recombination of the two materials is conducive to full contact with each other and electron transfer between the interfaces. Therefore, the oxygen adsorbed by MgAl-CLDH-g-C3N4 captures the electrons in the conduction band of g-C3N4 and a large amount of ·O2− is produced. The pollutants can be effectively degraded due to strong oxidation. The degradation products were diffused into the solution. Driven by the concentration gradient, the adsorption and photocatalytic cycle are carried out, until methylene blue is completely degraded to CO2 and H2O.

4 Conclusion

In summary, magnesium aluminum hydrotalcite and its derived metal oxides were prepared by simple co-precipitation and calcination methods on g-C3N4 nanosheets. Experiments and characterization methods showed that the visible light response range of g-C3N4 was broadened due to the incorporation of MgAl-CLDH to inhibit the photoelectron-hole recombination, and 97.3% methylene blue solution was degraded, with a degradation rate constant of 0.0432 min−1 within 1 h. The degradation rate of MgAl-CLDH were significantly higher than those of g-C3N4. And the good stability of multiple recycling was maintained. The improvement of photocatalytic performance of the composite is attributed to the "memory effect" of MgAl-CLDH-g-C3N4 and the increase of specific surface area to expose more catalytic active sites and adsorb more pollutants on the active sites, which provides a basis for photocatalytic degradation. Moreover, the composite of the two 2D structures is conducive to full contact with each other, thus enhancing the electron transfer between the interfaces and improving the photocatalytic performance. This ideal photocatalytic material has a good application prospect in the degradation of organic dyes and organic wastewater.

Declarations

Conflict of interest The authors declare that they have no conflicts of interest.

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Fig. 12 Photocatalytic degradation mechanism of MgAl-CLDH-g-C3N4 under visible light irradiation

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