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PRELIMINARY STUDY ON IMMOBILIZATION TECHNOLOGY OF TIO2 PHOTO CATALYST

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ARTICLE DETAILS

ABSTRACT

Article History:

Received 26 June 2018 Accepted 2 July 2018 Available online 1 August 2018 TiO_2 was used as photo catalyst to treat organic effluent firstly. Methyl orange solution was utilized as simulated wastewater for optimizing conditions of the reaction. That is: reaction time as 60min, solution concentration as 50 mg/L, and amount of catalyst as 0.02 g. TiO_2 was then immobilized on diatomite (so-called TiO_2 /diatomite composite materials) for treatment of organic effluent. The reaction mechanism was studied. The results showed that TiO_2 played as a good photocatalyst, diatomite possessed a certain adsorption capacity for methyl orange removal. The removal rate of 100% for advanced treatment of actual organic wastewater was obtained by using this composite material.

KEYWORDS

 TiO_2 , immobilization, diatomite, composite material, photocatalysis.

1. INTRODUCTION

 TiO_2 is recognized as the most effective semiconductor catalyst. Due to the low cost, large supply channels, high performance, and safety that are recognized through long-term social verification. There is significant potential in industrial-scale engineering applications for water/atmosphere purification [1-4]. However, in practical applications, there're many problems on suspended TiO_2 photocatalyst application, such as easy aggregation, difficulty in recovery, and secondary pollution caused by self-dispersion. Therefore, loading and fixing it on a suitable carrier is the key to the industrial processing application of the heterogeneous photocatalytic technology.

The diatomite has a diatom shell structure, large specific surface area, strong adsorption, high porosity, high temperature resistance and other excellent characteristics [5]. Its large specific surface area allows TiO_2 particles uniformly loaded on. On the other hand, its good adsorption properties make organic substances adsorbed on the surface, which increases the contact between organic matter and TiO_2 and probability increases the photocatalytic efficiency [6-10].

The preparation methods of $TiO_2/diatomite$ catalyst mainly include impregnation method, precipitation method and chemical deposition method [11, 12]. In this paper, $TiO_2/diatomite$ composites were prepared by coating method, and characterized by SEM and XRD. The catalytic degradation of organic wastewater was investigated. The influencing factors of the preparation method were discussed.

2. EXPERIMENT

2.1 Instruments and Reagents

TiO₂ (Degussa P25, Germany); Diatomaceous earth (filter with 0.3mm sieve for backup); Non-woven fabrics (purchased by Jilin Xiongfa Technology Co., Ltd., washed and dried repeatedly before use); Methyl orange (A.P.); The water sample of experimental wastewater comes from the second settling tank of a sewage treatment plant in Jilin city.BL-GHX-V photochemical reaction instrument (Shanghai Billon); UVmini-1240 spectrophotometer (Shimadzu Corporation, Japan); Sievers InnovOx laboratory TOC analyzer (US PE company).

2.2 Preparation of TiO₂/Diatomite Composites

First, a 10wt% TiO₂/diatomite homogenate was prepared and ultrasonically oscillated for 30 minutes. Then the homogenate was coated on treated non-woven fabric (15 cm*10 cm) for several times. After each coating, it was dried at 105°C for 1 hour to obtain a TiO₂/diatomite composite material.

3. RESULTS AND DISCUSSION

3.1 Optimization of Photocatalytic Reaction Conditions

In order to examine the combined effects of all main factors, an orthogonal optimization experiment of L9(3) was conducted. Here factor A is reaction time of 20min, 40min and 60min; factor B is the concentration of methyl orange with 40mg/L, 50mg/L and 60mg/L; and factor C is the amount of P25, which were 0.01g, 0.02g and 0.03g. The experimental results are shown in Table 1:

Table 1: Orthogonal test data

No.	Factor A	Blank	Factor B	Factor C	Degradation rate (%)
1	1	1	1	1	85.0
2	1	2	2	2	86.5
3	1	3	3	3	86.7
4	2	1	2	3	92.5
5	2	2	3	1	86.7
6	2	3	1	2	90.0
7	3	1	3	2	97.8
8	3	2	1	3	100.0
9	3	3	2	1	95.3
K_1	258.2	275.3	275.0	266.9	
K_2	269.2	273.2	274.3	274.3	
K_3	293.1	271.9	271.2	279.2	
R	34.9	3.4	3.8	12.3	

From Table 1, it can be seen that the highest degradation rate is obtained in the condition of $A_3B_1C_3$, which is 100%. According to the comparison of R as $R_A \!\!>\! R_C \!\!>\! R_B$, the main influencing factor is the reaction time, and then are the amount of catalyst and the concentration of methyl orange solution. Further analysis of K values (A column: $K_3 \!\!>\! K_2 \!\!>\! K_1$, B column: $K_1 \!\!>\! K_2 \!\!>\! K_3$, C column: $K_3 \!\!>\! K_2 \!\!>\! K_1$), the same optimized condition of $A_3B_1C_3$ was derived. But the final experimental condition of $A_3B_2C_2$ was decided in consideration of financial cost, which is reaction time was 60 min, the concentration of methyl orange was 50 mg/L, and the amount of P25 was 0.02 g.

3.2 Effect of the adsorption of methyl orange on catalyst carrier

3.2.1 Adsorption kinetics

In order to investigate the adsorption characteristics of the methyl orange solution, the absorbance of the methyl orange at different shaking times of the catalyst carrier were measured, and then converted into the removal rate

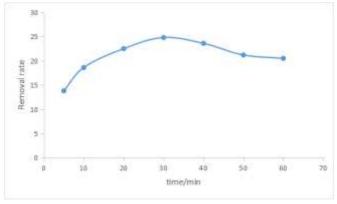


Figure 1: Removal rate of methyl orange with time

According to Figure 1, it can be seen that with the increasing of time, the removal rate gradually increases, and then reaches the maximum value of 24.8% at 30 min. After 30 min, the removal rate decreased a little, and then became stable. It indicates that catalyst carrier reach adsorption saturation after 30 min.

3.2.2 Adsorption isotherms

According to the relationship between the adsorption amount (G) and the equilibrium concentration (c) (Figure 2), the adsorption isotherm type for the adsorption of solution on the catalyst carrier belongs to be Freundlich type. It shows that the catalyst carrier has a certain adsorption capacity of methyl orange.

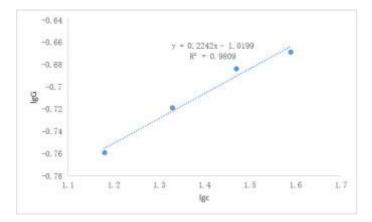


Figure 2: Adsorption isotherm of methyl orange solution by catalyst carrier

3.3 Repeatability Test of $TiO_2/Diatomite$ Composites

In order to investigate the durability of the composites, a 10wt% TiO_2 /diatomite composite material with good removal effect was subjected to repeated experiments under the above conditions.

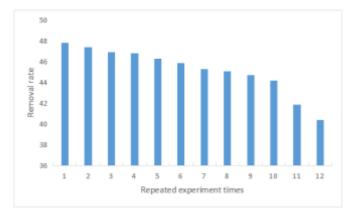


Figure 3: Repeated experiments

The results showed that the removal rate of methyl orange was slowly reduced to a certain extent beyond 44% at the former 10 times, and then reduce rapidly after 11 times. By weighing after every repeated experiment, the coated particles on the composite material were observed fallen off to a certain extent to 95.1%, which may caused the reduction of organic removal efficiency.

3.4 Characterization of TiO₂/Diatomite Composites

The SEM and XRD of the composites are shown in Figure 4 and 5, respectively.

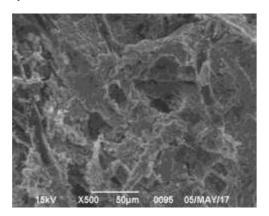


Figure 4: SEM of TiO₂/ diatomite composite material

According to figure 4, TiO_2 and diatomaceous earth were evenly covered on the surface of the nonwoven fabric can be observed.

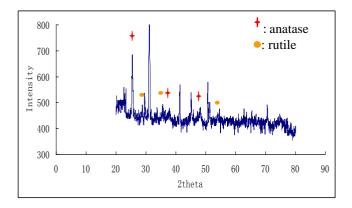


Figure 5: XRD of TiO₂/ diatomite composite material

The characteristic peaks of anatase appeared at 2θ =25.325, 37.841, 48.074, and the characteristic peaks of rutile appeared at 2θ =27.459, 36.104, 54.364. The XRD pattern of the tested composite material (Figure 5) can be determined the presence of both anatase and rutile phases. It indicated that the P25 component in the composite is uniformly distributed on the surface of the support, playing the role of catalytically active center. The experimental results showed that the composite material not only has an adsorption effect but also exhibits a good photocatalytic performance, which supports the above conclusions.

3.5 Advanced treatment of organic wastewater on $TiO_2/Diatomite$ composite

The 10% TiO_2 /diatomite composite material was applied for advanced treatment of the actual organic wastewater instead of methyl orange solution under the same experimental conditions. The result showed that the removal rate reached 100%, which is much better than the treatment of methyl orange simulated wastewater under the same conditions (the removal rate is 46.1%). It may be speculated that the actual organic wastewater composition is complex. Although the concentration of

organic matter is similar to that of methyl orange, the adsorption and catalytic degradation of composite materials maybe changed. Further study of the composite materials should be performed to investigate the reaction mechanism.

4. CONCLUSIONS

In summary, the TiO_2 /diatomite composite material owns both adsorption and photocatalysis effects. Organic pollutants can be adsorbed on the surface of the composite material and photocatalytic degradated to ideal content. This immobilization technology solves the recovery problem of TiO_2 suspended phase and has a good application prospect. However, it is necessary for further study on the loading method and durability.

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