

論文 / 著書情報
Article / Book Information

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(博士課程)
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論文要旨

THESIS SUMMARY

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系コース

申請学位 (専攻分野) : 博士
Academic Degree Requested Doctor of (Philosophy)

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要旨 (英文 800 語程度)
Thesis Summary (approx.800 English Words)

Magnetic carbon nanotubes-TiO₂ (MCNT-TiO₂) has becoming a promising photocatalyst for the photocatalytic degradation of pharmaceuticals as stated in **chapter 1**. However, based on the literature review in **chapter 2**, the current preparation methods of MCNT-TiO₂ are not environmentally friendly and the practical application of MCNT-TiO₂ is limited. Therefore, the objective of this study is to propose a novel approach to prepare MCNT-TiO₂ and assess the performance of the developed material for the removal of pharmaceuticals in water containing natural organic matter (NOM). This study will have two different targets: first, to synthesis of new MCNT-TiO₂ and secondly to evaluate its performance in simple aqueous solutions using ultrapure water (UPW) first, and then gradually increase the complexity by using real water matrix to mimic the full scale application of MCNT-TiO₂.

Current methods to prepare MCNT-TiO₂ include extensive use of chemicals which is against the environmental friendly application of photocatalysis. Novel MCNT-TiO₂ that rely on the inherent magnetic properties of carbon nanotubes were synthesized and their photocatalytic activity was evaluated for the degradation of carbamazepine and sulfamethoxazole under solar irradiation (**chapter 3**). This approach consumes less chemicals than the conventional method, while it utilizes the external surface of the nanotube walls for TiO₂ particles. Moreover, the resulting MCNT-TiO₂ showed high photodegradation rate, high magnetic response, and regeneration relative to the TiO₂ reference catalyst. This MCNT-TiO₂ is showing its potential application for the removal of organic/chemical contaminants in aqueous environment.

The performance of MCNT-TiO₂ was further systematically evaluated in the presence of NOM (**Chapter 4**). NOM has been found to interact with photocatalysts and inhibit the photocatalytic degradation process. To date, the understanding of the NOM inhibition mechanisms (e.g., ROS scavenger, inner filter, and competitive adsorption) in photocatalysis degradation of organic micropollutants by CNT-TiO₂ is limited. Therefore, three standard NOM samples (e.g., Suwannee River Humic Acid [SRHA], Suwannee River Fulvic Acid [SRFA], and Suwannee River NOM

[SRNOM]) were characterized, and their inhibition behaviors in MCNT-TiO₂ photocatalysis of pharmaceutical (i.e., carbamazepine) was examined. Terrestrially derived NOM with high aromaticity and large molecular weight was the major fraction of organic matter that participate in the inhibition. The results from model analysis indicated that the relative importance of NOM inhibition mechanism in MCNT-TiO₂ photocatalysis followed the order of ROS scavenging > inner filter effect > competitive adsorption. Yet, the reduction in photodegradation rate of carbamazepine using MCNT-TiO₂ were less than those of bare TiO₂ due to the higher surface area of MCNT-TiO₂ provided enough active sites for the reaction of pharmaceuticals on MCNT-TiO₂. Therefore, MCNT-TiO₂ showed great potential application as an advanced treatment depending on the quality of NOM.

The potential application of MCNT-TiO₂ as an advanced treatment was further confirmed for the removal of carbamazepine in filtrated secondary treated domestic wastewater (SWW) and filtrated river water (RW) and compared with SRNOM (**Chapter 5**). The overall carbamazepine removal results from various water matrices followed the trend of SRNOM 1 mg.C/L ($88.5 \pm 1.6\%$) > RW 1 mg.C/L ($86.9 \pm 0.28\%$) > SRNOM 3 mg.C/L ($79.82 \pm 0.14\%$) > SWW 3 mg.C/L ($41.4 \pm 12.79\%$). The performance of MCNT-TiO₂ photocatalysis in real waters are relatively lower than in the presence of SRNOM. Therefore, besides the NOM quality and quantity, the presence of other water chemistries (e.g., inorganic species, pH, ionic strength, etc.) also affected the MCNT-TiO₂ photocatalysis performance and should be considered for the performance assessment and optimization.

Overall, the photocatalytic degradation of pharmaceuticals in water containing natural organic matter was investigated using MCNT-TiO₂ composite. The novel approach utilizing the inherent magnetic properties of CNT facilitate more environmentally friendly (i.e., consumes less chemicals) preparation method than the conventional method, and MCNT-TiO₂ exhibits the photodegradation activity for the removal of pharmaceuticals depending on the quantity and quality of the NOM in the water. In this way, this study will contribute to bringing the MCNT-TiO₂ to the applied field (e.g., by reducing the cost for water treatment application and enhance the understanding of the applicability of MCNT-TiO₂ in real water). This novel analytical approach to understand each inhibition mechanisms in CNT-TiO₂ photocatalysis can also contribute in environmental management by providing the information for the model prediction and system optimizations to overcome the potential losses of efficiency due to the NOM inhibition. To this end, following points are recommended for future studies (**chapter 6**):

- Understanding the effect of various inorganic species and other water chemistries (e.g., pH, ionic strength, etc) in MCNT-TiO₂ photocatalysis.
- Detailed studies on the transformation products formation and their toxicity.
- Reactor design followed by testing system with MCNT-TiO₂ on pilot scale.

備考：論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。

Note：Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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