VIETNAM NATIONAL UNIVERSITY - HCMC
HO CHI MINH CITY UNIVERSITY OFTECHNOLOGY

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DISSERTATION INFORMATION

Title: ***Preparation of TiO_2-SiO_2/monolith photocatalyst for treatment of phenol residues in aqueous solutions***

Major: **Chemical Engineering** Major code: **9520301**

PhD candidate: **Ho Thi Ngoc Suong**

Advisors: **1: Assoc. Prof. Dr. Le Minh Vien**

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Major Contributions of This Dissertation:

The water environment is facing numerous pollution problems, particularly due to the hazardous organic waste from various industries. The discharge of these compounds into the environment without treatment can have negative impacts on the health of both humans and living organisms. Phenol is one of the most common organic pollutants contaminating water sources. The toxicity of phenol is evident even at low concentrations (5 ppm), making it essential to find effective and economical methods for phenol treatment. Advanced Oxidation Processes (AOPs) have emerged as a promising choice for phenol treatment in wastewater in recent years. Among all AOPs, semiconductor photocatalysts like TiO_2 are considered efficient catalysts for transforming organic pollutants into environmentally friendly products. However, commercial TiO_2 has wide bandgap energy (3.2 eV), relatively low specific surface area (50 m^2/g), and facile recombination of photo-generated electrons (e^-) with holes (h^+). TiO_2 exhibits activity only under UV light due to its wide bandgap energy. Additionally, the nano-sized TiO_2 catalyst in powder form presents difficulties for recovery and reuse after the treatment process. Nano TiO_2 catalysts Face many difficulties in practical applications for degrading organic compounds in water. Therefore, to exploit the potential of TiO_2 catalysts, modifications are needed to reduce the bandgap energy, decrease the rate of electron-hole recombination, and improve the surface area to enhance the efficiency of organic degradation. Furthermore, modified TiO_2 catalysts need to be immobilized on a carrier material (mechanically stable, suitable structure, and scalable) for further research on their practical applications.

The new contributions of the thesis include:

- This thesis has investigated the enhancement of the specific surface area of TiO_2 and the reduction of the bandgap energy to the UVA range.
- Successfully produced the photocatalyst Ag(3%)-TiO_2-SiO_2 composite (molar ratio Ti:Si = 95:5) in coated form on the channels of the monolith.
- Combine the use of Ag-TiO_2-SiO_2/monolith with the optical fibers to improve light transmission in the monolith channels, enhancing photocatalytic efficiency
- Improved the practical application of Ag-TiO_2-SiO_2/monolith with optical fiber support, potassium monopersulfate, and suitable operating conditions, making it easy to implement, recover, and reuse in water treatment applications.

The research has achieved the following results:

- Successfully synthesized TiO_2-SiO_2 composite (molar ratio Ti:Si of 95:5) with a specific surface area of 170.93 m^2/g, nearly three times higher than pure TiO^2 (64.61 m^2/g). The photocatalytic performance in the degradation of phenol at a concentration of 10 ppm with a catalyst dosage of 1.0 g/L significantly improved, increasing from 38.5% (TiO_2) to 91.5% (TiO_2-SiO_2) after 4 hours of phenol degradation under simulated natural light from a 26 W compact lamp. This indicates success in modifying the structure of TiO_2 with SiO_2, increasing the specific surface area and benefiting the photocatalytic process.
- After modification with 3% Ag (Ag:Ti ratio), the synthesized Ag(3%)-TiO_2-SiO_2 composite exhibited a reduced bandgap energy from 3.18 eV (TiO_2-SiO_2) to 2.93 eV (Ag(3%)-TiO_2-SiO_2). The phenol degradation efficiency of the Ag(3%)-TiO_2-SiO_2 material, under the same conditions, further increased by 6%, reaching 97.4%.
- Using a combined ultrasonic dipping technique, the Ag(3%)-TiO_2-SiO_2 composite has been successfully immobilized into a stable coating on the monolith. Raman spectroscopy revealed that the Ag(3%)-TiO_2-SiO_2 catalyst layer coated on the monolith exhibited a single-phase anatase. Surface and cross-sectional SEM images of the monolith materials proved that Ag(3%)-TiO_2-SiO_2 catalysts were successfully coated on the monolith surface. The EDX-mapping results also demonstrated that the Ag element had been

effectively integrated into the photocatalyst and uniformly deposited onto the surface of the TiO_2-SiO_2/SiO_2/monolith. The residual phenol removal efficiency under the investigated conditions decreased by only 8% after 4 reuse cycles. This indicates the durability of the catalyst layer coated on the monolith, exhibiting stable photocatalytic activity. The degradation performance, with the integration of optical fibers, increased by an additional 24% after 4 hours under the illumination of a 100 W LED light (395 nm), reaching 49.5%. The addition of potassium monopersulfate (1.0 mM) further enhanced the performance up to 99.5%, demonstrating superior improvement and effectiveness in the removal of water pollutants.

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