FABRICATION AND INVESTIGATION OF Fe_3O_4/Ag_3PO_4 PHOTOCATALYST ON THE SURFACE OF CERAMIC PAPER

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Abstract

The study aim on the fabrication and investigation of Fe_3O_4/Ag_3PO_4 photocatalyst on the surface of ceramic paper through precipitation method and immobilization of composite onto ceramic paper by in situ and filtration, impregnation method. The integration of magnetite (Fe_3O_4) and silver phosphate (Ag_3PO_4) on ceramic paper results in high performance efficiency of the material due to synergistic effect, improved charge separation, improved light absorption, stability and durability, increased surface area and active site. The ceramic paper supports uniform distribution of catalyst and since it can withstand high temperature, resist corrosion and chemical attack as well as possess excellent heat and electrical barrier, hence fabricated Fe_3O_4/Ag_3PO_4 photocatalyst on the surface of ceramic paper leads it to be applied for water treatment, photocatalysis and environmental remediation. Also, it has to be note that immobilization of the Fe_3O_4/Ag_3PO_4 photocatalyst on ceramic paper is of great importance due to the fact that ceramic paper prevent photocatalyst bleaching, allow good interaction of pollutants and catalyst surface due to porous structure, enhance durability and allows reuse over multiple cycles, in contrast most photocatalysts are tested on slurry suspension systems in which long term use is limited by particle aggregation, poor recovery and risk of secondary contamination.

Under this study, the photocatalytic activity of the fabricated photocatalyst will be assessed via methylene blue and methyl orange degradation experiment. The fabricated photocatalyst will be characterized by **X-ray diffraction** (XRD), Scanning electron microscopy (SEM), Energy dispersive X-ray spectroscopy (EDX) before and after degradation experiments.

Keywords: magnetite, silver phosphate, photocatalyst, ceramic paper, precipitation method, immobilization.

Introduction

The increasing contamination of water sources due to industrial and domestic activities has necessitated the development of efficient wastewater treatment technologies. Among various approaches, photocatalysis has emerged as a promising method for degrading organic pollutants in contrast to conventional treatment methods, are often unable to completely remove organic pollutants especially (POPs) leading to their accumulation in natural waters. Due to the phenomena photocatalysis has gained strong interest as a sustainable and efficient method for degrading persistent organic pollutants (POPs) into harmless end-products of CO_2 and H_2O.

When magnetite (Fe_3O_4**)** and silver phosphate (Ag_3PO_4) are combined in a Z-scheme heterostructure supported on **ceramic paper** offers an effective solution due to the fact that Fe_3O_4 provides magnetic properties for easy separation and enhances charge transfer, while Ag_3PO_4 provide strong visible-light photocatalytic activity. The ceramic paper serves as a stable, flexible, and heat-resistant substrate, improving the durability and allows reuse over multiple cycles of the photocatalyst. Therefore Fe_3O_4/Ag_3PO_4@ceramic paper composite in this

study is designed to efficiently degrade organic pollutants in wastewater under visible light, offering a practical and sustainable approach to water purification.

Experimental

Catalyst Synthesis

Silver phosphate (Ag_3PO_4) was synthesized via a precipitation method by reacting silver nitrate ($AgNO_3$) with various phosphate sources. Specifically, 0.2 M aqueous solutions of $AgNO_3$ and phosphate precursor of $NaH_2PO_4 \cdot 2H_2O$) were prepared separately and mixed in a 4:3 molar ratio under stirring. Upon mixing, a yellow Ag_3PO_4 precipitate formed rapidly. The mixture was stirred for an additional 10 minutes, then the product was collected by centrifugation, washed three times with Milli-Q water, and dried overnight at 40 °C.

Ceramic Paper Support

As a photocatalyst support, commercial Alsitra KP1250 ceramic paper was used. It consists of thermally stable mullite and polycrystalline alumina fibers, with high porosity and chemical resistance. Circular paper samples with a radius of approximately 22 mm were cut and used for catalyst immobilization.

Immobilization Techniques

Two approaches were explored for immobilizing the catalysts onto the ceramic paper:

1. **Filtration based deposition**
   A total of 50 mg of catalyst powder Fe_3O_4/Ag_3PO_4 was suspended in 100 mL of ethanol and ultrasonicated for uniform dispersion. The suspension was then vacuum-filtered through the ceramic paper discs. After filtration, the paper was dried at 40 °C overnight.
2. **In situ synthesis on ceramic paper**
   The ceramic paper was immersed in precursor solutions, and the synthesis reaction (e.g., Ag_3PO_4 precipitation) was allowed to proceed directly on the paper. For silver phosphate, equimolar solutions of $AgNO_3$ and phosphate salts (0.2 M) were sequentially added to the support by submersion, allowing the reaction to occur in situ. After synthesis, the papers were washed, dried, and stored under ambient conditions.

Photocatalytic testing of the immobilized catalysts is planned, while the activity of the powdered materials has already been confirmed in previous studies using methyl orange under visible light irradiation.

Results and discussion

We successfully immobilized photocatalytic nanomaterials onto ceramic paper (Alsitra KP1250) using two different approaches: filtration and in-situ synthesis. Scanning Electron Microscopy (SEM) confirmed the presence of the catalysts on the ceramic support as shown in **figure 1**.

The two immobilization techniques yielded markedly different outcomes:

- **Filtration method** resulted in a thick catalyst layer on the surface of the ceramic paper. The coverage was visually more uniform and continuous; however, the adhesion was weaker. Some material detachment was observed during handling and washing, especially at the edges.
- **In-situ synthesis** led to a more integrated catalyst layer with stronger adherence to the ceramic fibers. Although the coverage appeared less homogeneous and slightly patchy, the catalyst showed improved mechanical stability and resistance to washing.

In both cases, we observed partial leaching of the catalyst material, but the in-situ synthesized samples were noticeably more resistant to bleaching.

Photocatalytic activity of the immobilized catalysts has not yet been evaluated. Initial attempts were hindered by technical challenges: our current lab-scale reactor setup degraded the ceramic paper during testing due to poor physical compatibility. As a result, all photocatalytic performance evaluations so far refer only to the powdered catalysts before immobilization.
Despite these limitations, our immobilization strategies proved viable, and future tests using a modified or custom-built reactor (as outlined in our future plans) will focus on optimizing both durability and performance of the immobilized systems.

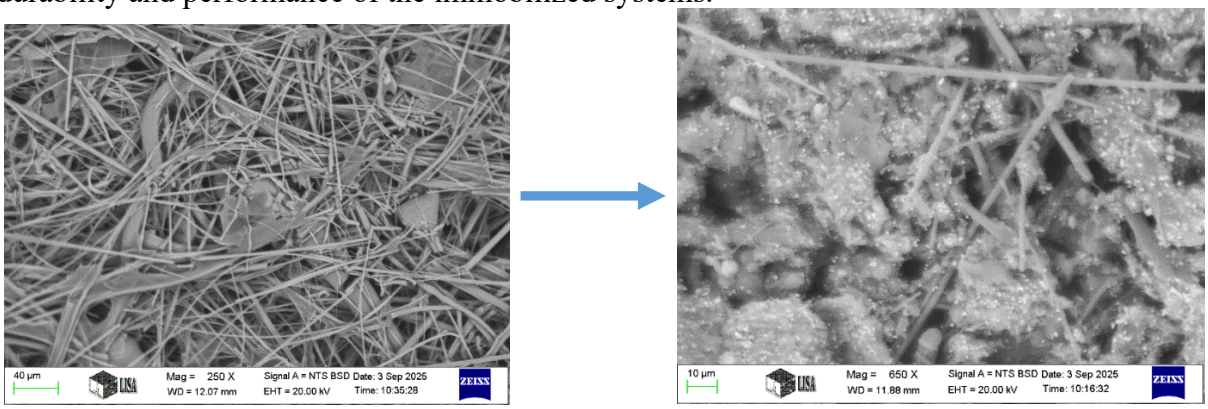

Figure 1: SEM image of ceramic paper before and after immobilized with Fe_3O_4/Ag_3PO_4

Conclusion

This study aims to bridge the gap between fundamental materials science and scalable environmental technologies by integrating catalyst synthesis, ceramic paper immobilization, and system-level design.

Acknowledgements

The authors are thankful for the financial support from NRDIO Hungary 2021-1.2.6-TÉTIPARI-MA-2022-00003.

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