Biocomposites of chitosan and Fe/Mn-TiO_2 and its solar photocatalytic activity on amoxicillin degradation

POSTER

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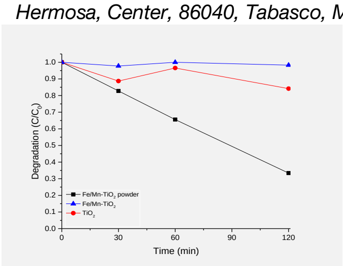

This study investigates the preparation of biocomposites of chitosan and Fe/Mn-TiO_2 and its efficacy in amoxicillin degradation under solar radiation. Fe and Mn codoped catalysts were prepared by sol-gel method and characterized by XRD and IR. Biocomposites were prepared by casting method. Their photocatalytic perform presents a reduction in the activity of the biocomposites compared to the powders, attributed to limitations in mass transfer and chitosan degradation.

Introduction

Heterogeneous photocatalysis has been well-known process potential for to oxidation of complex organic molecules, like amoxicillin (AMX). This characteristic is promised to implement such a wastewater treatment. However, the catalyst presentation is a challenge. Many strategies have been used to support the catalyst in this process. Chitosan biocomposites have been attractive due to their abundance of availability, low cost, and adsorption properties[1]. In another way, the activation of catalysts against solar radiation is the aim to reach a sustainability process, however many catalysts present low activation with this radiation. Metal co-doping has presented promised results to improve the photocatalytic activity of the catalyst[2]. This work presents the synthesis of Fe/Mn-TiO_2, the preparation of chitosan biocomposite and its performance on amoxicillin degradation under solar radiation.

Material and Methods

Synthesis: Fe/Mn-TiO_2 powders were synthesized by the sol-gel method. Titanium (IV) butoxide was mixed with butyl alcohol. The mixture was stirred for 30 min at room temperature. The pH 3 was adjusted using glacial acetic acid dropped. After 30 min, $FeNO_3$ and $MnSO_4$ solutions were dropped to gel formation. The gel was aged for 24 h at room temperature. Posteriorly, the gel was dried at 80°C for 48 h. Finally, the powder obtained was calcined with a ramp of 5°C/min and 450°C for 2h.

Preparation of biocomposites: Fe/Mn-TiO_2 biocomposites were synthesized by casting method[3]. Acetic acid solution (2 %w/w) was heated to 60°C under magnetic stirring. 0.25 g Fe/Mn-TiO_2 powder was added to the solution. Posteriorly, 0.50 g of commercial chitosan (low molecular weight, Sigma Aldrich) was added, and it was stirred (660 rpm) by 3 h at 60 °C. The mixture was transferred to a glass Petri dish 10 cm in diameter and subjected to 60 °C in a furnace for 24 h. Finally, the Petri dish with the film obtained was kept at room temperature for evaluation and characterization. TiO_2 biocomposite was prepared by similar conditions as control materials.

Characterization: Fe/Mn-TiO_2 and TiO_2 powders were characterized by X-ray diffraction (XRD), optical microscopy and IR spectroscopy. Cell parameters and cell volume were obtained by UnitCell program. Fe/Mn-TiO_2 and TiO_2 biocomposites were cut in a circular geometry of ~0.5 cm diameter means a commercial single-hole punch hoper and their mass distribution were determined.

Reaction conditions: In a volume reaction of 10 mL of 10 mg L^{-1} of AMX, 3 g L^{-1} of biocomposite or 1 g L^{-1} of powder was added. The photocatalytic performance of the materials was evaluated under natural solar radiation in June 2024 in CIIT, Apodaca, Nuevo Leon, Mexico (25.771823°, -100.11173°, EPSG: 4326 WGS84) between 10:00 h – 13:00 h approximately. The environmental conditions data were collected from the

Environmental Monitoring System (Sistema de Monitoreo Ambiental) of Nuevo Leon, México of *Apodaca* and *Pesquería* stations. HPLC-DAD followed the AMX degradation. The kinetic of degradation was adjusted by the pseudo-first-order reaction. By multivariable statistics, the correlation between AMX degradation, characterization results, and environmental conditions.

Results and Discussion

Figure 1 shows the XRD patterns of Fe/Mn-TiO_2 and TiO_2. The anatase phase (RRUFF ID R060277) was determined. Fe or Mn oxides phases were not identified. However, a right displacement of Fe/Mn-TiO_2 suggests a co-doping due to Fe and Mn atomic radius are lower than Ti atomic radius. Also, the crystallite size was of 11.5 nm and 10.2 nm to TiO_2 and Fe/Mn-TiO_2 respectively. The *a* and *c* cell parameters and cell volume were 3.78 Å, 9.52 Å and 136.13 Å^3 to TiO_2 and 3.78 Å, 9.49 Å and 136.00 Å^3 to Fe/Mn-TiO_2, due to a cell contraction by metal co-doping indicated that Fe or Mn are incorporated substitutional into lattice crystalline of TiO_2 [2].

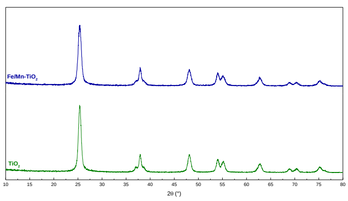

Figure 1. XRD patterns of TiO_2 and Fe/Mn-TiO_2 powders.

The figure in **Graphical abstract** presents the photocatalytic evaluation of powders and biocomposites for 120 minutes. It is observed a reduction in photocatalytic activity of biocomposites compared to powders, this it attributed to mass transfer limitations. Additionally, chitosan may present a degradation during the degradation. To comprobed this, IR of biocomposites after used were record in **Figure 2** and **Figure 3**, that compared to biocomposites before used, the signals of 1541 cm^{-1} to 896 cm^{-1} to Fe/Mn-TiO_2 presented a transmittance reduction.

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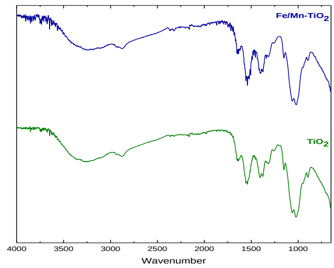

Figure 2. IR spectra of TiO_2 and Fe/Mn-TiO_2 biocomposites.

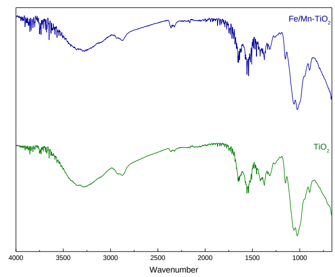

Figure 3. IR spectra of used TiO_2 and Fe/Mn-TiO_2 biocomposites.

Conclusions

Biocomposites of chitosan and Fe/Mn-TiO_2 show potential for amoxicillin degradation under solar radiation, but their efficiency is lower than that of catalytic powders due to limitations in mass transfer and possible degradation of chitosan.

Acknowledgments

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