A Synergistic Approach Based On The Union Between TiO_2, ZnO, And Sepiolite Was Applied To The Removal Of Ciprofloxacin Hydrochloride.

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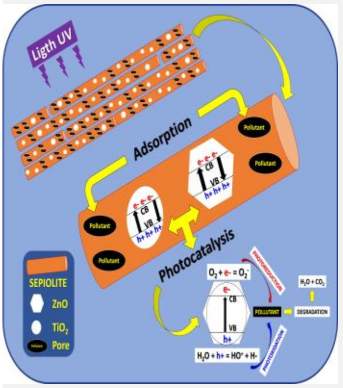

Aquatic pollution poses challenges to water reuse, requiring sustainable depollution methods. Here, a novel catalyst of sepiolite, titanium dioxide (TiO_2), and zinc oxide (ZnO) was synthesized for ciprofloxacin hydrochloride (Cipro) removal from water. The catalyst efficiently removed pollutants under UV light, leveraging photocatalytic and adsorption properties. Characterization techniques verified catalyst formation and effectiveness, including XRD, XRF, DRS, SEM, and EDS. Notably, the 5Zn-Ti-Sep catalyst demonstrated the highest removal efficiency, suggesting cost-effective depollution solutions for improving water quality and preserving aquatic ecosystems.

Introduction

Aquatic pollution poses significant challenges to water reuse, necessitating sustainable and efficient depollution methods [1-4]. A novel catalyst has been proposed comprising sepiolite, titanium dioxide (TiO_2), and zinc oxide (ZnO). This catalyst integrates the photocatalytic properties of TiO_2 and ZnO with the adsorption capabilities of sepiolite, targeting the removal of pollutants such as ciprofloxacin hydrochloride (Cipro).

This study aims to develop a cost-effective solution for aquatic depollution treatments, enhancing water quality for human consumption and the well-being of aquatic ecosystems.

Material and Methods

The photocatalyst was synthesized using zinc oxide (ZnO), titanium dioxide (TiO_2), and sepiolite (Sep), resulting in three samples: Ti-Sep (1:4 ratio); 1.5Zn-Ti-Sep (1.5% ZnO); 5Zn-Ti-Sep (5% ZnO). The removal efficiency was evaluated under the following conditions: Cipro concentration at 30 ppm; 100 mg of catalyst; 125 W Ultraviolet (UV) lamp; 45 minutes in the dark followed by 180 minutes under illumination; constant stirring at a temperature of 25°C; and reuse tests conducted over three cycles. Characterization of the catalysts was performed using X-ray Fluorescence (XRF), X-ray Diffraction (XRD), UV-vis Spectrophotometry with Diffuse Reflectance (DRS), and Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectrometer (EDS).

Results and Discussion

The XRD results (Fig. 1) and XRF data (Tab. 1) indicate the formation of a new product from the combination of Zn, TiO_2, and sepiolite. The interaction between Ti and sepiolite enhanced absorption in the visible light spectrum.

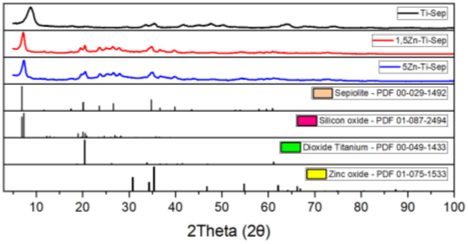

Figure 1. XRD patterns of Ti-Sep, 1.5Zn-Ti-Sep, and 5Zn-Ti-Sep superimposed on the PDF charts of the identified phases (author's own).

Increased Zn content resulted in higher band gap values (Fig. 2a, 2b). The decrease in Urbach energy suggested widening the band gap (Fig. 2b), consistent with a reduction in oxygen defect density [4].

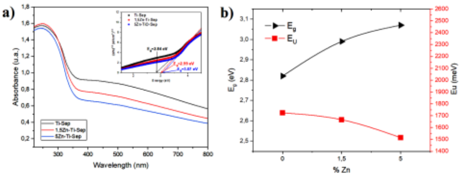

Figure 2. DRS spectrum graphs with band gap (via Tauc graph) (a), Band gap (E_g), and Urbach energy (E_u) due to Zn variation (b)

SEM analysis (Fig. 3a, 3b, 3c) confirmed the typical morphology of sepiolite: layers arranged in long ribbons that intertwine to form fibers [3], [5]. The EDS analysis of 5Zn-Ti-Sep displayed a uniform distribution of constituent atoms on the surface, with notable oxygen dispersion (Fig. 3d, 3f).

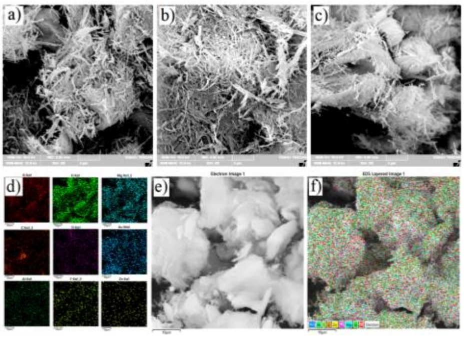

Figure 3. SEM images of TiO_2-Sep (a), 1.5Zn-Ti-Sep (b), and 5Zn-Ti-Sep (c), (e). SEM-EDX images of 5Zn-Ti-Sep with elemental mapping (d), (e), (f) (author's own).

The characteristic absorption peak of Cipro gradually diminished with increasing illumination time (Fig. 4a, 4d). However, the results suggest that the majority of Cipro was primarily removed through adsorption (Fig. 4a). Notably, 5Zn-Ti-Sep exhibited the highest removal efficiency (Fig. 4a, 4b, 4e) and decomposition reaction rate constant (Fig. 4c). Additionally, adsorption tests (Fig. 4f) confirmed the predominance of adsorption over photocatalysis in Cipro removal, with 43.92% achieved in just 5 minutes.

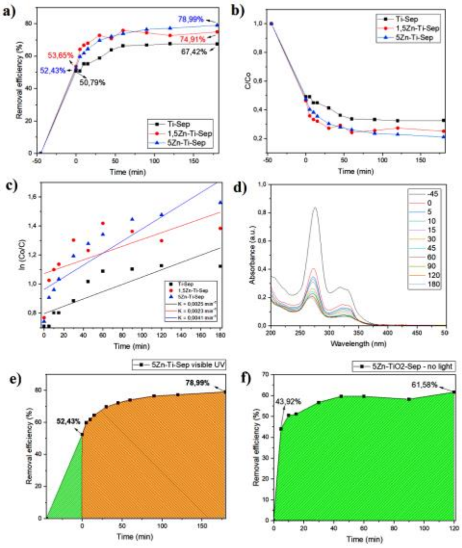

Figure 4. Graphs with Cipro removal efficiency (a) and rates (b), kinetic modeling first order (c). 5Zn-Ti-Sep graphs: UV-Vis spectrum with Cipro removal over time (d); Cipro removal efficiency via adsorption and photocatalysis with UV light (e) and without light by adsorption (f). (author's own).

Table 1. XRF of samples Ti-Sep, 1.5Zn-Ti-Sep, 5Zn-Ti-Sep (author's own).

Ti-Sep		**1,5Zn-Ti-Sep**		**5Zn-Ti-Sep**	
MgO	18,758 %	**MgO**	18,269 %	**MgO**	16,919 %
SiO_2	52,835 %	**Al_2O_3**	1,814 %	**Al_2O_3**	1,673 %
K_2O	0,598 %	**SiO_2**	51,477 %	**SiO_2**	49,381 %
CaO	0,201 %	**P_2O5**	0,296 %	**K_2O**	0,607 %
TiO_2	26,388 %	**K_2O**	0,576 %	**TiO_2**	25,314 %
Fe_2O_3	1,221 %	**CaO**	0,206 %	**Fe_2O_3**	1,104 %
		TiO_2	24,753 %	**CuO**	66,3 ppm
		Fe_2O_3	1,023 %	**ZnO**	4,946 %
		ZnO	1,587 %	**Br**	500,9 ppm

Conclusions

The synthesized catalyst comprising sepiolite, TiO_2, and ZnO demonstrated promising results in removing Cipro from aquatic environments. The combination of photocatalytic properties and adsorption capabilities effectively addressed the challenges posed by aquatic pollution, offering a cost-effective solution for water depollution treatments. The study's findings highlight the potential of this catalyst in enhancing water quality for human consumption and preserving aquatic ecosystems.

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