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Equilibrium and Kinetic Study of Photocatalytic Degradation of Tartrazine Using Biochar Using Microwave Assisted Pyrolysis From *THEOBROMA CACAO L. Husk Doped With Iron.*

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INTRODUCTION & AIM

The escalating contamination of water bodies with synthetic dyes poses a significant threat to aquatic ecosystems. Conventional wastewater treatment methods often struggle to effectively remove these persistent pollutants. This study explores the potential of iron-doped cacao husk biochar (BCCPH-Fe) as a sustainable and efficient photocatalyst for the degradation of tartrazine, a common azo dye. By leveraging the adsorptive properties of biochar and the catalytic activity of iron, BCCPH-Fe aims to provide a promising solution for the remediation of dye-contaminated wastewater.

The primary goal of this research is to investigate the effectiveness of iron-doped cacao husk biochar (BCCPH-Fe) in the photocatalytic degradation of tartrazine at various experimental conditions. This includes evaluating the influence of factors such as pH, light source, BCCPH-Fe dosage, tartrazine concentration, and exposure time on the degradation efficiency. Additionally, the study explores the adsorption kinetics and equilibrium of tartrazine onto BCCPH-Fe, shedding light on the underlying mechanisms involved in the degradation process. Ultimately, the goal is to establish the feasibility of BCCPH-Fe as a sustainable and efficient alternative for the treatment of dye-contaminated wastewater.

METHOD

The first step was an acid pretreatment of cacao husks, followed by a milling process to reduce particle size, followed by sieving to obtain a uniform distribution. Subsequently, an acid pretreatment was carried out using a 0.5 M HCl solution to remove lignin and hemicellulose, thereby enhancing the accessibility of the cellulose component. The pretreated biomass was then washed thoroughly to remove residual acid and dried to ensure complete removal of moisture. To obtain iron-doped biochar, the pretreated biomass was subjected to pyrolysis in a microwave oven. The resulting biochar was then chemically modified using iron sulfite and sulfate precursors to introduce iron ions, obtaining this way BCCPH-Fe.

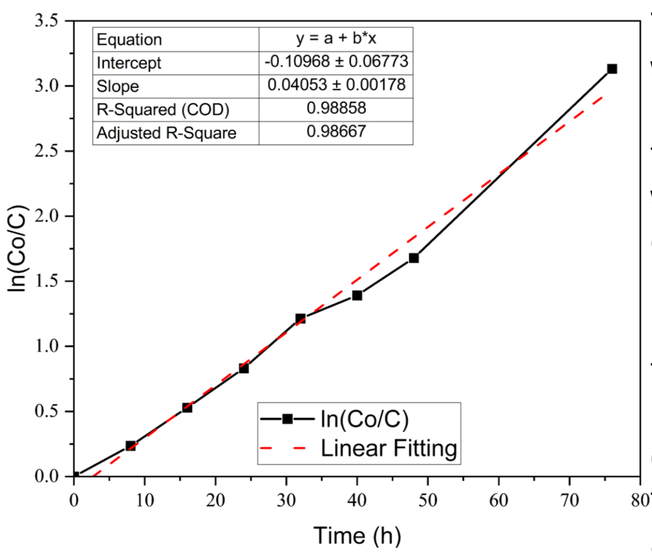
BCCPH-Fe was further characterized using various techniques to determine its physicochemical properties, including surface area, pore volume, and iron content.

Tartrazine degradation experiments were conducted at varying conditions to optimize the process parameters. Different light sources were tested to evaluate their effectiveness. The pH of the solution was adjusted to determine its influence on tartrazine degradation and the catalytic activity of the biochar. The amount of biochar added to the solution was also varied to investigate its impact on the degradation rate. Additionally, the initial concentration of tartrazine was varied to assess the biochar's ability to degrade different levels of the pollutant. To monitor the degradation process, the concentration of tartrazine was measured at regular intervals using a UV-VIS spectrophotometer. The degradation efficiency was calculated based on the reduction in tartrazine concentration over time. The optimal conditions for tartrazine degradation were determined based on the highest degradation efficiency achieved.

RESULTS & DISCUSSION

Iron-doped biochar was synthesized and characterized to assess its potential for tartrazine photodegradation. FTIR analysis confirmed the successful incorporation of iron onto the biochar surface, evidenced by the presence of characteristic peaks associated with Fe-O and Fe-O-OH bonds. However, the impregnation of iron particles led to a decrease in the biochar's surface area, as determined by BET analysis. This reduction was attributed to the blocking of micropores by iron particles, which also resulted in a broadening of the pore size distribution.

Equilibrium studies were conducted to identify the optimal conditions for tartrazine photodegradation. The results indicated that UV light with a wavelength of 254 nm was most effective, likely due to its higher energy compared to longer wavelengths. A pH of 5 was found to be optimal, suggesting that the negatively charged surface of the biochar at this pH facilitates the adsorption of tartrazine molecules. Additionally, a biochar mass of 1 g was determined to be the ideal amount, as increasing the mass beyond this point did not lead to significant improvements in photodegradation. However, a tartrazine concentration of 25 ppm was found to be the equilibrium point, beyond which increasing the concentration did not result in further photodegradation.



Kinetic studies were performed to investigate the reaction mechanism. The Langmuir-Hinshelwood model was found to accurately describe the photodegradation process, suggesting that the reaction is pseudo-first-order with respect to tartrazine concentration. This implies that the rate of photodegradation is directly proportional to the concentration of tartrazine molecules. The apparent kinetic rate constant (k_{ap}) was determined to be 0.04053, indicating the rate at which tartrazine molecules are degraded under the given conditions. A high correlation coefficient (R^2) of 0.98667 further supports the accuracy of the Langmuir-Hinshelwood model.

CONCLUSION

Iron-doped biochar has demonstrated promising potential for tartrazine photodegradation. The optimal conditions for photodegradation were identified, and the kinetic behavior was successfully modeled using the Langmuir-Hinshelwood equation. However, further research is necessary to elucidate the underlying mechanisms of photodegradation, explore the scalability of this technology for practical applications, and investigate its potential for treating other organic pollutants.

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