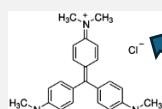
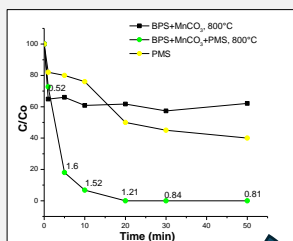


Manganese-enriched carbonaceous material obtained from banana residues for carbocatalytic treatment of pharmaceuticals emerging contaminants

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A carbonaceous material obtained from agricultural banana residues (pseudo stem) modified with MnCO_3 and FeCl_3 at 800°C was prepared, characterized, and used to activate peroxymonosulfate (PMS) against crystal violet and methyl orange. The best performance carbocatalytic of the material was obtained with a working pH (pH 7). For systems with low adsorption, the carbocatalysis is synergic. The metallic ion used in the structural modification plays a role in the degradation relationship with oxidation power, interaction with PMS and counterion metallic for synthesis evolution.

Introduction

Colombia ranks among the world's top banana producers, yet a mere 30% of the bananas are utilized during harvest, leaving behind a large amount of waste. This waste includes the banana pseudo-stem, which holds considerable promise for various applications and added value uses. In this context, turning banana pseudo-stem into carbon-based materials (CM) not only minimizes waste but also enhances resource efficiency.

Studies have shown that carbonaceous materials (CM) derived from cellulose sources like sawdust and plant stems can effectively remove dyes, heavy metals, and pharmaceuticals from the environment. However, there's limited research on using these materials as catalysts for advanced oxidation processes (AOPs). AOPs are characterized by the formation of oxidizing species, such as hydroxyl radicals, at ambient temperature and pressure. These radicals are crucial for degrading pollutants, as they can react through various pathways, including hydrogen abstraction, addition to unsaturated systems, and electron transfer. Due to their high reactivity, hydroxyl radicals can effectively break down a wide range of aliphatic and aromatic organic compounds, making them excellent for removing organic pollutants of human origin. Peroxymonosulfate (PMS) is frequently used in AOPs due to its relatively low cost and its ability to generate oxidizing species from carbon-based substrates through carbocatalysis, producing free radicals that can efficiently degrade organic molecules. Additionally, the presence of transition metals within carbonaceous matrices plays a crucial role in enhancing matrix activation during carbocatalysis [1-5].

This study examined the degradation performance

of a concept molecule cationic (violet crystal) and (orange methyl) using a carbonaceous catalyst derived from banana residues. The research compared the results by varying both the activating metal (manganese and iron) and the carbon source to understand how these factors influence the degradation process.

Material and methods

Banana residues were collected from agricultural activities in southwestern Colombia. This material was pyrolyzed at 500°C for 5 hours in a muffle with a heating ramp of $100^\circ\text{C}/\text{h}$. Chemical activation was then performed with MnCO_3 and FeCl_3 using a 1:1 (carbon: metal ion) impregnation ratio, at 800°C for 1 hour following the same heating ramp compared with raw material at the same temperature. Once the modified carbonaceous material was obtained (BPS) at 800°C , and its modifications (BPS+ FeCl_3) and (BPS+ MnCO_3). The pH with distilled water until reached a pH of 7.

Adsorption degradation and carbocatalysis experiments were carried out at a concentration of 0.0306 mM (cationic and anionic molecule), using 0.5 mM PMS (for carbocatalysis), natural pH, and 100 mg of the material carbonaceous.

The reaction was monitored through a UV-Vis spectrophotometer to $\lambda = 580\text{ nm}$.

Results and discussion

The three carbonaceous materials (raw, iron-modified, and manganese-modified) exhibited high adsorption with methyl orange and little effect on carbocatalysis. However, for molecules with a residual positive charge like crystal violet, little adsorption is observed, there is a moderate effect of PMS, and high carbocatalytic efficiency. The synergy values increase from the raw material (BPS)

to the material modified with transition metals, with the manganese-modified material showing the highest catalytic enrichment compared to iron. The electronic properties of iron(III) are comparable to those of manganese(II), but the influence of PMS on

the metal ions may lead to the stabilization of different oxides with oxidizing capacities that could synergistically contribute to degradation.

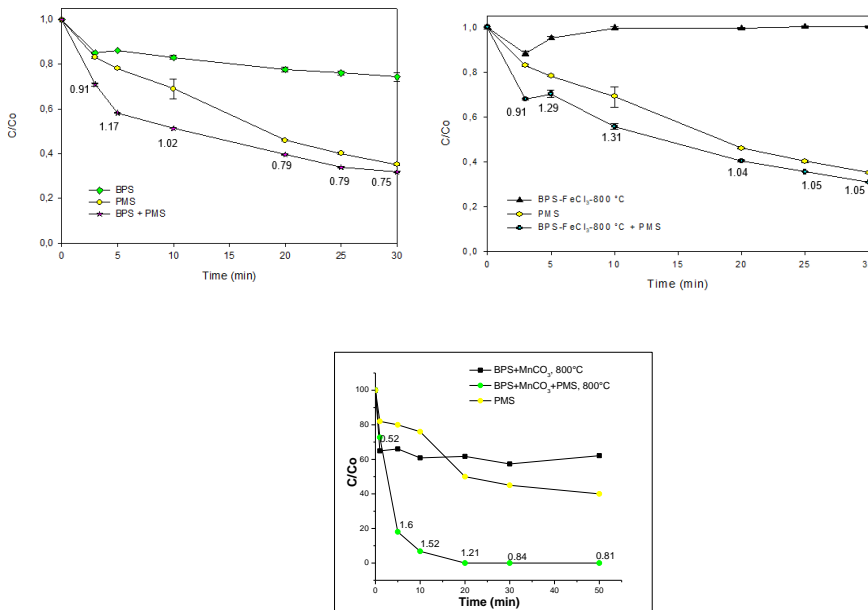


Figure 1. Degradation of violet crystal with BPS and its modification with iron(III) and manganese(II), a). BPS (raw material to 800°C), b), c). BPS modified with manganese and iron.

Conclusions

In this study, banana residues were used to obtain a carbocatalyst, which was modified with MnCO₃ and FeCl₃, and used as an activator of PMS in the degradation of anionic and cationic molecules. The adsorption with orange methyl is high and its carbocatalytic role is low. However, for positive charge molecules, the adsorption is a low and high synergistic process with PMS. The metal ion increases the synergistic capacity for degradation in relationship with the exfoliated thermic of raw material (BPS). The role of manganese can be associated with metallic oxides stabilized to high temperatures to promote the best oxidation activity. The voltammetry and spectroscopy studies are completed to understand the redox potential in the catalytic process and dicloxacillin, trimetropin, sulphamethoxazole, and acetaminophen will be the target of analysis in future degradations.

Acknowledgments

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