Exploring the photocatalytic potential of HKUST in the degradation of dyes in textile effluents

POSTER
Ph.D. Student: Y
Journal: Y

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The textile industry generates effluents with a high concentration of pollutants, including dyes, surfactants and suspended solids, causing environmental concerns. Conventional treatment methods are limited for this waste due to the low biodegradability of dyes. Advanced oxidative processes, such as photocatalysis, have emerged as an alternative. H-KUST has a high surface area and can act as a catalyst. The study analyzed the efficiency of H-KUST in the degradation of three textile dyes (yellow, red and turquoise) through photocatalysis. The tests carried out showed that H-KUST had promising results in degrading yellow and turquoise dyes by approximately 50%. Therefore, H-KUST could be an effective option for the treatment of textile effluents through photocatalysis.

Introduction

The growing concern about the environmental damage caused by the industrial activities of the textile sector has become one of the main challenges for the conservation of water resources, since it is one of the main polluters of surface water due to the high consumption of this resource and of chemical products during manufacturing processes. The effluents generated by the textile industry are characterized by toxic compounds and when disposed of inappropriately in effluents, they result in damage to ecosystems [1,2].

Conventional treatment techniques are not suitable for removing color and dissolved organic compounds due to the low biodegradability of many dyes [1]. However, Advanced Oxidative Processes (AOPs) have been identified as an alternative for the removal of pollutants with a high organic load. In this sense, photocatalysis has emerged to modify and degrade organic compounds [3].

MOF H-KUST has a significant surface area and a porous structure made up of rectangular pores. It is a highly hydrophilic material, which allows water molecules to bind to the copper (II) centers [4]. The aim of this study is to analyze the potential of H-KUST in the degradation of textile dyes during the photocatalysis process.

Material and Methods

For the photocatalytic experiments, tests were first carried out on the concentration curve of each dye used to analyze the best absorbance (ABS close to 1), which is the ideal concentration for dilution. Next, 3 solutions were prepared containing 3 types of dye: Neutracyl Millary Yellow 2R dye with a concentration of 0.0625g/L, Quimacryl Red GTL dye with a concentration of 0.0625g/L and Quimacryl Turquoise 5G dye with a concentration of 0.007813g/L, mixed with distilled water, to simulate artificial effluents, and then the zero absorbance was measured for each dilution of the textile dyes. Next, approximately 0.1 g of H-KUST was weighed into 9 separate beakers (triplicate). Subsequently, 100 mL of each dye solution was added to the beakers. The solutions were taken to the stirring reactor with ultraviolet light (18W German lamp) for the photocatalysis process, which lasted approximately 120 minutes. Samples were taken every 30 minutes, for a total of 4 samples from each beaker. These samples were read on the spectrophotometer in order to monitor the efficiency of H-KUST in degrading the dyes tested.

To synthesize H-KUST, two solutions were mixed, one of 720 g of copper II nitrate trihydrate in 1200 mL of a mixture of N,N-dimethylformamide and ethanol, and the other of 360 g of trimesic acid in 4800 mL of a mixture of equal volumetric parts of N,N-dimethylformamide and ethanol, both under mechanical stirring until completely solubilized and homogenized. The prepared mixture was placed in an oven at 85 °C for 24 hours for the MOF formation reaction. After thermal synthesis, the blue solids

were recovered by common filtration and then dried at 150 °C for 5 hours, obtaining the final product H-KUST.

Results and Discussion

Through the photocatalytic tests, absorbance data was obtained for the reaction time and, in this way, it was possible to construct the graph showing the ratio between the absorbances collected every 30 minutes and the initial absorbance by time, as shown in Figure 1, which compares the degradation of the three types of dyes in the presence of H-KUST in a photocatalytic reaction.

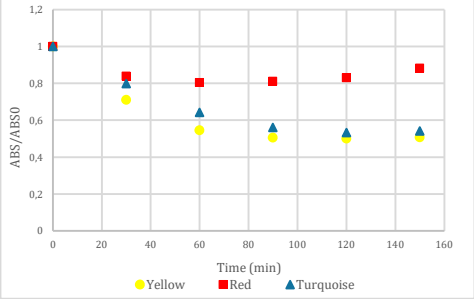

Figure 1. Photocatalysis of effluents with H-KUST.

Equation 1 was used to calculate the percentage of effluent degradation in order to verify the effectiveness of HKUST and fatocatalysis.

$$\% \text{ degradation} = \frac{Abs0 - Absultimate}{Abs} \quad (1)$$

The results are shown in Table 1.

Table 1. Percentage of Degradation

Dye	ABSzero	ABSfinal	%
Yellow	2,77	1,4057	49,25
Red	1,6327	1,4402	11,79
Turquoise	1,0227	0,5539	45,87

According to the graph and the degradation percentage, it was possible to see that H-KUST obtained promising results in relation to the yellow and turquoise dyes, in which there was a degradation of the dyes of approximately 50%. However, degradation was lower for the red dye, indicating that the use of H-KUST for this color or wavelength is not as effective. In order to improve the results, it is recommended to study the use of promoting agents, which are aids in the photocatalysis process, helping to degrade the residues in the effluent, increasing their degradation potential..

Conclusions

Tests using H-KUST in photocatalytic reactions show that for the degradation of yellow and turquoise dyes in aqueous media it achieved a degradation potential of 49.2% and 45.8% respectively, in other words, around 50% of the residue present in the water is eliminated. As for the red dye, H-KUST was unsatisfactory, degrading only 11.7% of the dye in aqueous solution. This shows that although studies on the use of H-KUST in photocatalysis are recent, this type of MOF could be promising in the treatment of textile effluents in order to promote the degradation of environmentally toxic dyes. In general, the use of H-KUST for photocatalytic reactions could be greatly improved by new studies and applications in this area.

Acknowledgments

For CNPQ, the Araucária Foundation, UTFPR for their financial support and to our research group.

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