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Coordenador:
Rafael Salomão

Organizador(es):
Ana Carolina Figueiredo Prado
Bianca Groner Queiroz
Claudia Santana Goncalves Ferreira

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Removal of indigo dye from industrial textile effluent by adsorption using ZnO

G. C. Mendonça[1], M. I. B. Bernardi[2]

[2]*Universidade de São Paulo, Escola de Engenharia de São Carlos, SP, Brazil*
e-mail: gcerrim@usp.br

Abstract

Pollution of river and groundwater results in various health risks to living beings, most chemical contaminants in groundwater and surface water come from industrial and agricultural sources. These waters must be treated, and nowadays various methods are being studied, such as adsorption. In this work ZnO was used as adsorbent of indigo dye. The evaluation of the adsorption was performed according to the color removal and monitored by spectrophotometry. The results indicated that the treatment was effective in color removal.
Keywords: ZnO. Adsorption. Textile Effluent, Indigo, Wastewater Treatment.

Introduction

Adsorption has shown to be a promising technology for retaining organic contaminants while minimizing the impact on ecosystems. In general, this method is based on the concentration of solids on the surface of substances present in fluids, occurring the separation. This process can be accomplished by a semiconductor nanoceramic, helping to reduce the time and cost of traditional biological processes[1].

ZnO nanoparticles are gaining prominence due to their semiconducting and optical properties. Several studies have been conducted with metal oxide nanoparticles to develop more efficient ways to treat textile effluents to reduce their toxicity[2].

The motivation for this work is the growing concern for the environment, especially for the maintenance of water resources, where industrial effluents are often disposed of improperly and without pretreatment. The use of adsorption helps in the reduction of dissolved organic compounds in surface water and groundwater from a semiconductor, and is considered an efficient method, sustainable in the long term, without the need for prior treatment, and also allows the recovery of the adsorbent.

Experimental Procedure

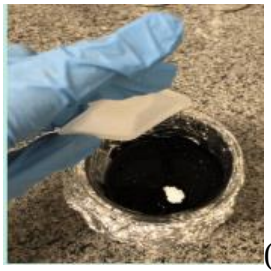
The ZnO nanoparticles with addiction of 1, 3 and 5% rare earth Cerium were synthesized by coprecipitation: Zn1CeMCO, Zn3CeMCO and Zn5CeMCO. After synthesized they were characterized by:

- X-ray diffractometry;
- BET;
- UV Spectroscopy;
- Raman spectroscopy;
- SEM;
- Zeta Potential and DLS;

The effluent was collected in a denim industry, located in the city of São Carlos - SP. This effluent comes from the dyeing process of cotton yarns, so it was necessary to perform a 400 mesh sieve to remove the cotton fibrils in the effluent.

Figure 1: Textil effluent.

The adsorption tests were carried out in the Chemical Synthesis Laboratory in the Physics Institute of the University of São Paulo. The adsorption test was performed in batch mode, and consisted in the addition of 0.100g of adsorbent in contact with 200mL of adsorbate, the textile effluent. The flasks were left in constant agitation for a period of 24 hours. The concentration of the raw textile effluent was determined by spectrophotometry in a UV-VIS spectrophotometer apparatus in the absorbance mode, after it was centrifuged for 3 minutes at 14.2 RPM. The mixture was centrifuged for 3 minutes at 14.2 RPM and the indigo dye concentration was determined via spectrophotometry.



(A)

(B)

(C)

Figure 2: (A) Catalyst addiction. (B) Adsorption. (C) Centrifugation.

Results and Discussion

In Figure 3 are results the XRD, RAMAN and SEM.

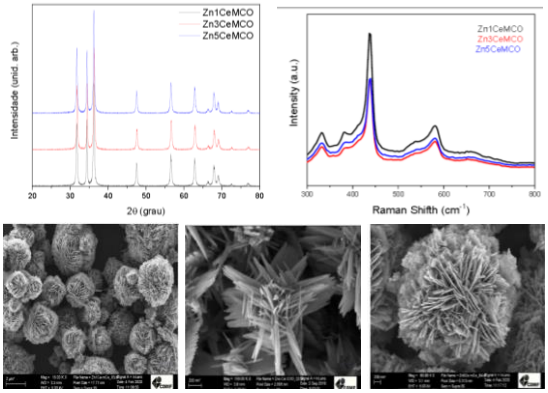


Figure 2: Characterization.

All X-ray diffractograms showed single phase, and the diffraction peaks are associated with the crystalline planes of the hexagonal structure (wurtzite) of ZnO.

In the Raman spectrum, three main modes of ZnO were identified centered at approximately 330, 382 and 435cm-1. The presence of the main vibrational modes of ZnO in the samples confirms the hexagonal structure of wurtzite[3]. The morphologies obtained showed that the synthesi method present hedgehog shape. The band gap of the samples varied for Zn1CeMCO with 3.27 eV, for Zn3CeMCO 3.24 eV and Zn5CeMCO with to 3.22 eV.

The results of the adsorption process for Zn1CeMCO nanoparticle was 95.15% indigo removal, for Zn3CeMCO was 93.72% and for Zn5CeMCO was 94.89% removal. In the Figure 3 shows the visual result of color removal from adsorption with these three nanoparticles compared to the raw effluente.

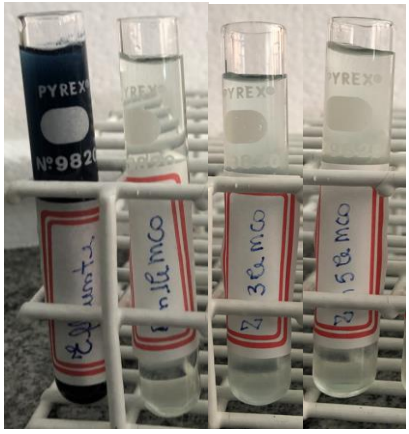


Figure 3: Result of adsorption.

In comparison with the literature, no work out of [4] can be observed that the removal of indigo dye color from textile effluent was increased with increasing concentration of the solute used, where used also [in a ceramic material, which was bentonite clay, ranging from 60.97 ± 0.29% to 98.27 ± 0.09% (after decanting) and from 74.00 ± 0.48% to a maximum of 99.21 ± 0.01% (after centrifugation).
Therefore, the present work achieved satisfactory and surprising results in terms of indigo removal with nanomaterials.

Conclusions

It can be seen that ZnO plus Cerium is very attractive and stands out among the other oxides, obtaining various morphologies and easy and low cost synthesis. The fabrication and characterization of the nanoceramics were effective and satisfactory results were obtained in all synthesis methods. For their use as adsorbents, the results of indigo removal in raw textile effluent were surprising.

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