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WOOD SAWDUST POWDER FROM *CORYMBIA CITRIODORA* TO CONGO RED TOXIC DYE ADSORPTION

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ABSTRACT The wood sawdust powder adsorbent from *Corymbia citriodora* was studied to remove the textile congo red dye (CR) in aqueous medium. The results showed that the higher adsorption rates of dye by sawdust assessment were observed at pH 4.0 and 7.0, stirring time at 5 minutes and 5.0 g of adsorbent mass. This adsorption system provided a maximum adsorption capacity of 0.523 mg/g using the Langmuir mathematical model. The results suggest that such adsorbent material is capable of removing congo red dye in aqueous medium. In addition, the present work provides another alternative for the use of wood dust residue from sawmills in Espírito Santo State, Brazil.

KEYWORDS : adsorption, Sawdust assessment, congo red dye

1. Introduction

Various pollutants have been detected in water supply such as heavy metals [1], benzene, toluene, ethylbenzene, p-xylene [2], Phenol [3], pesticides [4], radioactive elements [5] and textile dyes [6] are among the most found in rivers, lakes and other aquatic environments. In many countries, the contaminated effluents from textile industries are discharged in the aquatic environmental without the correct treatment [7]. The presence of this pollutant diminishes the solubility of gases, causes cumulative effects in various organisms and toxic effects on human beings. Some textile dyes, such as congo red (CR), may be potentially carcinogenic [8]. Thus, it is necessary to develop or improve of efficient technologies capable of removing textile dyes present in the water. Treatments such as photochemical reaction [9], bioremediation [10] and adsorption [7] are among the most evaluated. One of the most studied is adsorption using natural adsorbents [11]. Compared to other processes, the adsorption, using natural adsorbents, is low cost, employs material of great availability and finally presents efficiency in the removal of several types of pollutants [12]. The sugarcane bagasse is able to remove dyes [7] and drugs [13]. The Coconut mesocarp was investigated in the removal of tetracycline and paracetamol [14], as well as vermicompost was able to adsorb dyes [15] and metals [16]. Banana peel was studied to remove the pollutant acetylsalicylic acid [17] and dyes in aqueous medium [18]. Wood sawdust is abundantly generated by timber industries and has been studied for the removal of textile dyes and heavy metals [19]. Finally the Eucalyptus wood (*Eucalyptus globulus*) sawdust treated using sodium hydroxide proved to be efficient for removal of congo red dye in aqueous medium [20]. In this work we evaluated the wood sawdust powder from Eucalyptus *Corymbia citriodora* (WSPECC) for the adsorption of congo red dye (CR) in aqueous medium. This species of eucalyptus is abundant in Brazil. In order to evaluate the adsorptive efficiency of this material, the following procedures were performed: washing and drying of WSPECC, physico-chemical analysis of the WSPECC surface, influence of the pH, stir time between CR and WSPECC, WSPECC mass, CR concentration and finally determination of the maximum adsorption capacity (MAC) of WSPECC to CR.

2. Materials and methods

2.1. Materials

The wood sawdust powder from Eucalyptus *Corymbia citriodora* was obtained from loggers located in the Espirito Santo State, Brazil. Congo red dye (Figure 1) and hydrochloric acid were purchased from Vetec Company (Duque de Caxias-RJ, Brazil). Sodium hydroxide was obtained from Dinâmica (Diadema-SP, Brazil). The following equipment was used in laboratory tests: laboratory oven (Quimis Q-317 B model), particle size sieves (Granutest), Analytical balance (Shimadzu AY 220 model), sputter coater (Shimadzu, IC-50 Ion Coater model), scanning electron microscope (Shimadzu, SSX 550 model), infrared spectrophotometer (Perkin-Elmer Spectru -100 model), pHmeter (PHTEK), magnetic stirrer (Nova Ética) and UV/Vis spectrophotometer (Biospetro SP-220 model).

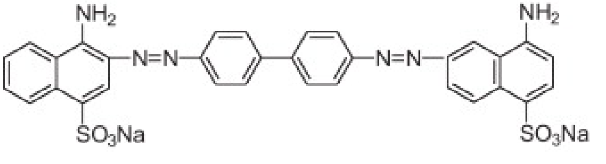

Figure 1. Congo red dye structure.

2.2. Methods

2.2.1. Washing and drying of WSPECC

The WSPECC was washed with hydrochloric acid 0.1 M and pH was adjusted to 7.0 using sodium hydroxide. Subsequently the adsorbent material was dried in a laboratory over for 10 hrs at 50C. Finally the WSPECC was sieved to obtain particles sizes between 1.19 mm and 4.76 mm.

2.2.2. Physical chemistry analysis of WSPECC

For the analysis of the surface, the particles samples of WSPECC were first covered with a thin layer of gold using the sputter coater. Then the surface of these samples were visualized in scanning electron microscope (SEM) with image magnification at x500 and x1000 (electron beam of 10 kV). Subsequently, the chemical analysis was performed through infrared spectroscopy (IR) to detect the presence of chemical groups capable of interacting with CR dye. The presence of these groups is very important in the adsorptive process. This methodology was performed by Fourier transform IR spectroscopy using KBr discs to prepare the WSPECC samples. The spectral range varied from 4000 to 500 cm^{-1} as described by [17].

2.2.3. Evaluation of magnetic stirring time, adsorbent mass, and pH

The aqueous solutions containing 25 mg/L CR dye were magnetically stirred for 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 minutes respectively at 1000 rpm in different pH (4.0, 7.0, and 9.0). The solutions were stirred at different WSPECC mass (0.10, 0.25, 0.3, 0.5, 1.00, 1.25, 1.50, 2.00, 2.50, and 3.00 g). The objective of this step was to evaluate the parameters: contact time between the dye and the adsorbent, pH of the dye solution and adsorbent mass for efficient adsorption. After each procedure, the solutions were filtered for retention of the adsorbent. The supernatants were analyzed in a spectrophotometer at 500 nm to evaluate the amount of dye retained in the adsorbent. These experiments were performed as described by [7].

2.2.4 Influence of CR concentration and determination of the maximum adsorption capacity (MAC) of WSPECC to CR

The maximum adsorption capacity (MAC) represents the amount of adsorbate which can be adsorbed by 1 g of adsorbent. Therefore, the influence of increasing CR concentrations on the adsorption process was evaluated. The procedure employed 50 ml of different concentrations (0.1 to 30 mg L^{-1}) of the dye solutions at 25°C ± 1°C and pH 7.0. Posteriorly the CR solutions were magnetically stirred for 5 minutes at 1000 rpm using 1.5 g of WSPECC mass. The parameters: stirring time, adsorbent mass, and pH of CR solutions were previously established in 2.2.3. Finally, the results obtained in this procedure allowed the MAC value determination using the Langmuir mathematical model as described in [17].

3. Results and Discussion

3.1. SEM and IR analysis of WSPECC

The scanning electron microscopy demonstrated that the adsorbent powder has an irregular surface with concavities of different sizes (Fig. 2). The presence of this surface rich in irregularities increases its surface area and can make it efficient in the adsorption of a pollutant [17]. Similar SEM results were found in other natural adsorbents that were also efficient in the removal of pollutants in water [13], [14], [17],[20].

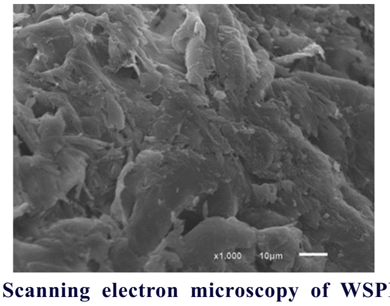

Figure 2. Scanning electron microscopy of WSPECC with magnifications of 1000x.

The chemical functional groups analysis performed through infrared spectroscopy. The presence of these chemical groups is mainly due to the occurrence of biomolecules such as hemicellulose, cellulose, proteins and lignin [17]. The IR spectro (Figure 3) obtained from the WSPECC showed that important functional chemical groups are present in this natural material able to interact with congo red dye. Among these groups are: C-O (1,028 cm^{-1}), probably due to axial deformation present in C-O-C system and carbonyl group (C=O) probably in the 1,606 cm^{-1} band, since it is in the range between 1,800 and 1,540 cm^{-1}. However the conjugation of the carbonyl with phenyl group it may cause an additional reduction in the absorption frequency of the C=O (1,606 cm^{-1}). Additionally, the C-H sp^3 from methyl group can be indicated in 2,914 cm^{-1} and O-H group probably from the alcohols in 3,343 cm^{-1} [21].

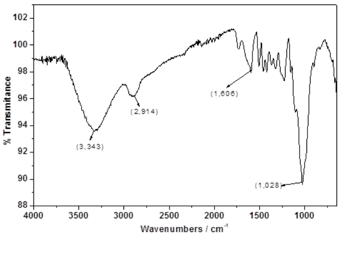

Figure 3. IR spectro of wood sawdust powder from Eucalyptus *Corymbia citriodora*

3.2. Evaluation of magnetic stirring time, adsorbent mass, and pH

The CR dye (25 mg/L) aqueous solutions were magnetically stirred to obtain the best contact time, better solution pH and better WSPECC mass in order to a satisfactory maximum adsorptive capacity in the subsequent experiment (3.3). The best stirring time was obtained in 5.0 minutes. From this time the percentage of adsorption remained constant and reached equilibrium (Figure 4). The test that evaluated the influence of the mass of the adsorbent showed that the maximum percentage of CR adsorption was obtained in the presence of 1.5 g of WSPECC (Figure 5). Finally the optimization tests were concluded with the pH evaluation. The results showed the maximum adsorption in pH 4.0 and 7.0 (Figura 6). We chose pH 7.0 because it is the most used in water treatment plants [17].

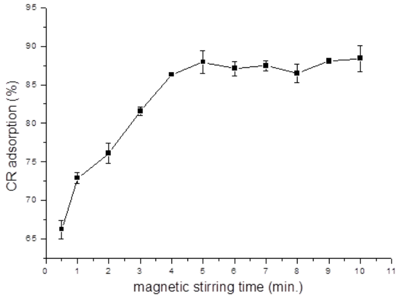

Figure 4. Influence of magnetic stirring time (1000 rpm) in CR adsorption in the presence of WSPECC.

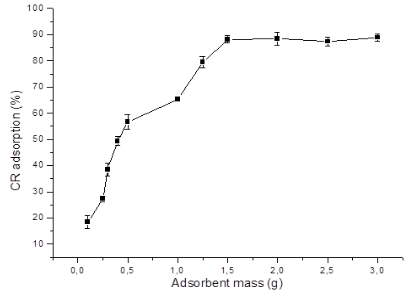

Figure 5. Influence of WSPECC mass in CR adsorption.

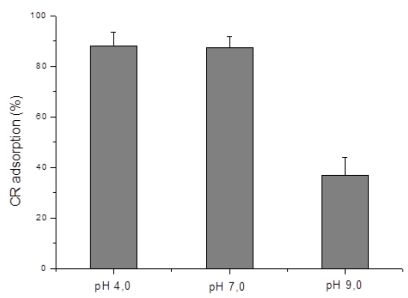

Figure 6. Influence of pH in CR adsorption in the presence of WSPECC.

3.3. Determination of the maximum adsorption capacity of WSPECC to CR

The influence of CR dye concentration on the adsorption process by WSPECC was evaluated to determination of maximum adsorption capacity (MAC). The results obtained in this procedure allowed the MAC value determination. For this the mathematical model of Langmuir was employed as described in detail in [15]. and [17]. The data obtained through the calculations of this model allowed the elaboration of the graphic containing maximum amount of CR retained in the WSPECC in the equilibrium (q) as a function of the equilibrium constant (EqC) (Figure 7). After the linearization of this graphic (Figure 8) it was possible to obtain WSPECC MAC (0.523 mg/g) for CR.The MAC value is in accordance with other values presented by other natural adsorbents for CR and other dyes [7], [15].

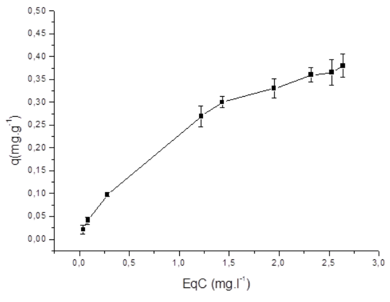

Figure 7. graphic containing maximum amount of CR retained in the WSPECC in the equilibrium (q) as a function of the equilibrium constant (EqC)

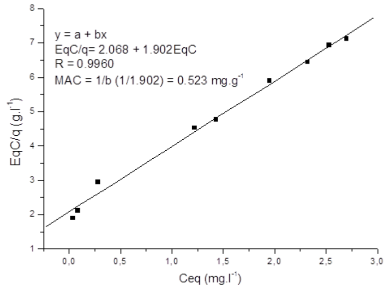

Figure 8. Graphic linearized containing EqC/q (y) and EqC(x) for obtaining MAC value.

4. Conclusion

The results suggest that WSPECC has characteristics that qualify it as a possible natural adsorbent for water treatment containing congo red dye. This material showed satisfactory maximum adsorption capacity. Finally, the results encourage more detailed studies, including the retention of other textile dyes e various pollutants such as heavy metals, drugs, hydrocarbons, pesticides and others.

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