Textile Waste Valorization: a Potential Catalyst for Oxidation of Organic Pollutants

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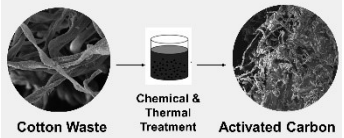

Catalytic wet peroxide oxidation is a promising method for wastewater treatment, encompassing the synergistic effects of activated carbon catalysts and hydrogen peroxide. This work presents the synthesis of a catalyst composed of activated carbon from textile waste for application at catalytic wet peroxide oxidation (CWPO). The carbon was obtained by chemical activation and impregnated with iron from foundry sand. Cotton-activated carbon showed satisfactory efficiency, promoting more than 90% degradation of methylene blue after 30 minutes of reaction. This finding highlights the eco-friendly catalyst's potential to face water pollution challenges by providing a sustainable solution for wastewater treatment.

Introduction

The textile industry has been expanding rapidly due to population growth, economic growth, and fashion cycles. In recent years, the upward of the textile sector has led to the generation of large amounts of waste. It is estimated that more than 92 million tons of textile waste are generated annually [1].

Several practices have been employed to manage this waste, such as disposal in landfills, incineration, reuse, and recycling. However, around 75% of textile waste still ends up being sent to landfills and incineration [2]. This practice causes serious environmental issues because textile waste is less biodegradable and decomposes slowly. Therefore, recycling and reuse are effective strategies for managing this waste.

Biomass-based activated carbon has been widely explored in water treatment due to its high carbon content [3]. Although the effectiveness of textile waste as a precursor material for activated carbon has received attention from the scientific community, the use of these wastes for synthesizing catalytic materials is still limited.

In this context, the present work aimed to develop a catalyst from textile waste and evaluate its performance in the catalytic wet peroxide oxidation (CWPO) process facing the degradation of methylene blue dye.

Material and Methods

Iron recovery from foundry sand

Iron was obtained through acid digestion of foundry sand in acetic acid. Firstly, 20 g of sand was added to 20 mL of acetic acid solution and 2 mL of H_2O_2 (10%). The solution was left to rest for 24 h and then heated until it reached 70 °C. Then, 4 mL of ammonium hydroxide was added, and heating was maintained for 3 min. After, the solution was filtered, and the filtrate was dried for 24 h at 100 °C and then calcined in a muffle furnace at 600 °C for 1 h. The iron was separated using a magnet.

Synthesis of activated carbon

To obtain cotton carbon, firstly 0.5 g of recovered iron was added to 150 mL of distilled water. Hydrochloric acid (0.1 mol L^{-1}) was added to this solution until pH 2. The solution was transferred to 50. 6 g of moistened cotton waste with distilled water. The residue was placed in an ultrasonic bath for 30 minutes and then in an oven at 80 ºC for 17 h. After that, 160 g of the residue was carbonized in a muffle furnace for 4 h in a tubular steel reactor at 500 ºC, under an N_2 atmosphere. For the activation process, the pyrolyzed carbon was added to a Potassium Hydroxide solution (25% w/w) and taken to the ultrasonic bath for 1 h. Finally, the carbon was taken to the oven at 100 ºC for 21 h. The synthesized carbons were characterized by scanning electron microscopy (SEM) images (graphical abstract) and Energy dispersive X-ray spectroscopy (EDS).

Catalytic oxidation of methylene blue

The effectiveness of cotton carbon was evaluated against MB oxidation at pH 3, 5 and 11. In 200 mL of MB solution (0.06 g L^{-1}) 0.25 g of activated carbon was added and after 30 minutes, time to reach the equilibrium of adsorption, 230 µL of H_2O_2 was added (stoichiometric amount required to oxidation of the dye). The reaction remained under stirring for 30 min and at predetermined time intervals, aliquots were taken, filtered through a syringe filter, and read on the UV-Vis spectrophotometer (ʎ= 665 nm). Assays

were performed in duplicate. The efficiency of activated carbon was compared with commercial carbon under the same conditions described above.

Results and Discussion

Table 1 summarizes the elemental composition analysis of textile waste carbons. The carbons had a high carbon and oxygen content, followed by the presence of the elements potassium, chlorine and iron. The presence of iron only in activated carbon suggests that activation was responsible for the effectiveness of iron fixation on the carbon surface.

The efficiency of cotton carbon in removing MB at different pH values is shown in Figure 1 (a). The maximum adsorption of MB onto activated carbon was 88.2% and 89.3% at pH 5 and 11, respectively. These results highlight the adsorptive potential of carbon from textile waste. As for the oxidation of MB by CWPO, similar behavior was observed at the different pH values studied. In 30 min of reaction, activated carbon promoted the degradation of 90.9%, 91.1% and 90.4% at pH 3, 5 and 11, respectively.

Given the great efficiency of activated carbon under the conditions studied, we chose to carry out the comparison study with commercial carbon at pH 5, as this is the pH of the MB solution (Figure 1 (b)). While activated carbon promoted the adsorption of 88.2% of dye, commercial carbon adsorbed only 26.6%. In 30 minutes of CWPO, commercial carbon promoted 54.6% of MB degradation compared to 91.1% of degraded by activated carbon. The high efficiency obtained by cotton carbon is explained by the presence of Fe, since Fe in combination with H_2O_2 results in the generation of the hydroxyl radical, a highly active oxidant capable of degrading organic molecules.

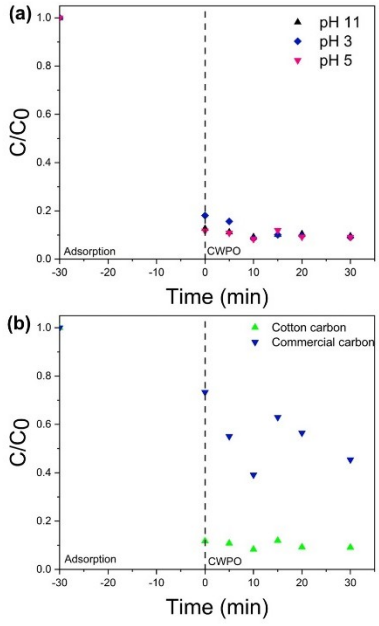

Figure 1. Efficiency in the catalytic oxidation of methylene blue: (a) activated carbon from textile waste (b) cotton carbon and commercial carbon at pH 5.

Table 1. Elemental composition of carbon from textile waste.

Sample	Elementary Composition (% Weight)					
	C	O	K	Cl	Mg	Fe
Non-activated carbon	84.98	11.55	3.44	0.01	0.01	-
Activated carbon	27.93	38.41	31.93	0.59	1.00	0.14

Conclusions

Textile waste was successfully employed as a precursor for activated carbon synthesis. The impregnation of iron recovered from foundry sand proved to be effective, providing the degradation of organic pollutants, obtaining degradation efficiency above 90%. Therefore, the results obtained in the present work contribute to the search for alternatives for the management of textile waste.

Acknowledgments

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