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Study Of The Removal Of Victoria Pure Blue And Azo Dye Orange II Dyes Using *Peltophorum Pteocarpium* Seed Pods Activated Carbons Prepared By Different Activation Methods

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Abstract

Activated carbons were prepared from an agricultural waste, *Peltophorum Pteocarpium* seed pods by using pyrolysis, sulphuric acid, zinc chloride and sodium hydroxide activation methods. These activated carbons were used as adsorbents for the removal of Victoria pure blue and Azo dye Orange II dyes from aqueous solutions. Batch adsorption studies such as effect of contact time, pH and dosage were carried out.

***Key words*:** Adsorption, *Peltophorum pteocarpium*, Activated carbon.

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1 Introduction

Water is one of the important ecosystems for the existence of the biotic species. If we do not save the water properly it would lead to loss of biodiversity. Textile, industrial and agricultural wastes significantly pollute the water sources. Many industries such as the textiles, paper, leather, plastics industries are extensive dye users. The textile industries are the first by quantity and quality of dyes used for the dyeing of various fibre types. Wastewaters from the textile industries contain in addition of dyes, a large number of other polluting matters such as toxic organic residuals, acids, base and inorganic matters. Some dyes are carcinogenic and mutagenic being formerly produced from dangerous chemicals such as benzidine, metals etc. Dyeing industries is one of the largest water consuming industries. In most situations, the use of combination of different methods of treatment is necessary in order to remove all the contaminants present in the wastewater.

Adsorption process is the most powerful technique and used for removing organic and inorganic pollutants from wastewater and it is embodied in carbon adsorption systems and ion exchangers. Activated carbon is the most common adsorbent for the removal of many organic contaminants. The adsorption process of activated carbon, however, is prohibitively expensive, which limits its application. Therefore, there is a need to

produce activated carbon from cheaper and readily available materials. In the past years, several investigations have been reported the removal of dyes using activated carbons developed from industrial or agricultural wastes. Also several studies of dye removal were carried out using adsorbents developed from natural materials.

2. Materials and methods

2.1. Preparation of *Peltophorum pteocarpium* activated carbon using pyrolysis

Peltophorum pteocarpium seed pods collected from local area were washed with distilled water, dried at 105 ±5ºC and pulverized between 300 to 800µm particle sizes. The material was kept in Muffle furnace and carbonized at 400^0C. Then the material was cooled to room temperature and activated using same furnace at 600^0C for 20 minutes. After activation process, the carbon was washed with deionized water and dried at 105±5ºC in hot air oven. Then the carbon was again sieved between300 to 800µm and stored in an airtight bottle.

2.2. Preparation of *Peltophorum pteocarpium* activated carbon with H_2SO_4

The 300 to 800µm size *Peltophorum pteocarpium* seed pods were treated with conc. sulphuric acid in the weight ratio 1:1 till charring was over and heated in an electric hot- air over at 130-160ºC for 8 hrs. The carbonized material was washed with distilled water to remove the excess acid and dried at 105ºC to remove moisture. Then the carbon is impregnated with a 1% sodium bicarbonate solution for 24 hours to remove any free acid if present. It was then washed well to remove excess bicarbonate, dried at 105ºC and again sieved between 300 to 800 µm particles. Then the carbon was sieved and stored in an air tight bottle.

2.3. Preparation of *Peltophorum pteocarpium* activated carbon with $ZnCl_2$

The 300 to 800µm size *Peltophorum pteocarpium* seed pods were impregnated with 1% boiling solution of zinc chloride and soaked for 48hrs.The excess $ZnCl_2$ solution was decanted off and air dried. The material was kept in Muffle furnace and carbonized at 400^0C. Then the material was cooled to room temperature and activated using same furnace at 600^0C for 20 minutes. After activation process, the carbon was washed with deionized water and dried at 105±5ºC in hot air oven. Finally the carbon was again sieved between 300 to 800µm and stored in an airtight bottle.

2.4. Preparation of *Peltophorum pteocarpium* activated carbon with NaOH

The 300 to 800µm size *Peltophorum pteocarpium* seed pods were impregnated with 1% boiling solution of sodium hydroxide and soaked for 48hrs. The excess NaOH solution was decanted off and air dried. The material was kept in Muffle furnace and carbonized at 400^0C. Then the material was cooled to room temperature and activated using same furnace at 600^0C for 20 minutes. After activation process, the carbon was washed with deionized water and dried at 105±5ºC in hot air oven. Then the carbon was again sieved between 300 to 800µm and stored in an airtight bottle.

The pictures of *Peltophorum pteocarpium* seed pod which was selected for the preparation of different types activated carbon was shown below in Fig 1.

Figure.1. *Peltophorum pteocarpium* seed pod

Physico-chemical characteristics of activated carbons through different methods such as pyrolysis, sulphuric acid, zinc chloride and sodium hydroxide were studied to analyse particle size (Å), pore volume, half pore width (mode), specific gravity, surface area m^2/g, volatile matter %, and Methylene Blue number mg/g using standard methods.

Two different dyes such as Victoria pure blue and Azo dye orange II dyes were used to study the dye removal efficiency of different activated carbons prepared by pyrolysis, sulphuric acid, zinc chloride and sodium hydroxide methods. Batch adsorption studies were carried out to optimize time interval, pH and carbon dosage using 0.001% of dye solutions.

3.Results and discussion

3.1 Physico-chemical characteristics

Characteristics of carbon determine their dye degradation capacity from wastewater system. Pore size is an important factor to determine the quality of activated carton (Swiaztkowski and Goworek 1987; Buczek *et al*., 1995; Ahmedna and Rao, 2000; Derylo-Marzewska *et al*., 2004; Yin *et al*., 2007; Lim *et al*., 2010; Yang and Qiu 2011;). When particle size of the activated carbon is smaller, surface area, pore volume, Methylene blue number and specific gravity were increased which was reported by Lim *et al*., (2010) and Saeidi and Lotfollah, (2015). The characteristics of carbon activated through different selected methods showed that pore volume, surface area, volatile matter were high in sulphuric acid method prepared activated carbon. Particle size, half pore width and Methylene blue number were good in pyrolysis method activated carbon. The specific gravity was high in sodium hydroxide method(Table 1).

Table 1. Characteristics of carbon activated through different selected methods

Parameters	Pyrolysis	Sulphuric acid	Zinc chloride	Sodium hydroxide	P Value	F Value
Particle size Å	63.33±1.53	92.33±0.58	85.00±1.00	75.00±1.00	<0.0001	406.40

Pore volume	0.28±0.0044	0.37±0.0015	0.36±0.0020	0.31±0.0021	<0.0001	719.52
Half pore width (mode)	8.27±0.05	8.18±0.05	8.23±0.02	8.25±0.02	0.0900^{ns}	3.086 ^{ns}
Specific gravity	0.84±0.01	0.94±0.02	0.86±0.02	0.97±0.01	<0.0001	46.700
Surface area m^2/g	583.17±2.85	684.69±0.67	625.06±0.59	618.81±0.74	<0.0001	2246..30
Volatile matter %	21.47±1.04	25.61±0.17	23.27±0.69	24.69±0.15	0.0002	24.29
Methylene Blue Number mg/g	174.00±1.00	92.33±0.58	111.67±0.58	134.00±1.00	<0.0001	5523.80

3.2 Effect of contact time

The effect of contact time was studied using 100 ml of dye solution using 1 g of selected activated carbon adsorbent at pH 5.0 for varying periods with 15 min intervals. The results obtained for the removal of Victoria pure blue and Azo dye Orange II dyes from aqueous solution using selected activated carbons were shown in Fig.2 and Fig 3 as shown below.

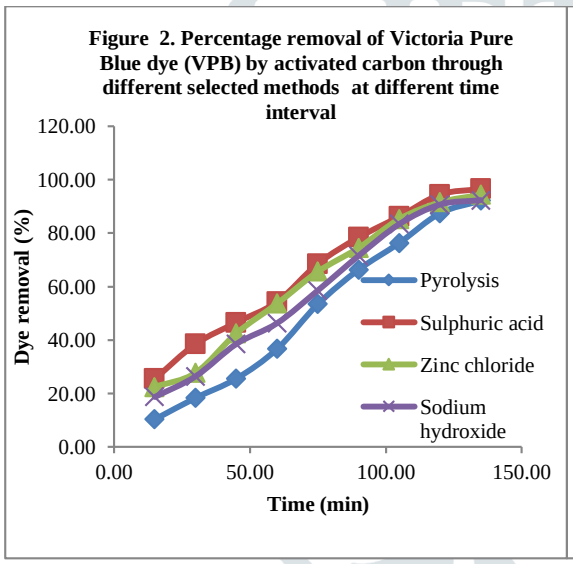

Figure 2. Percentage removal of Victoria Pure Blue dye (VPB) by activated carbon through different selected methods at different time interval

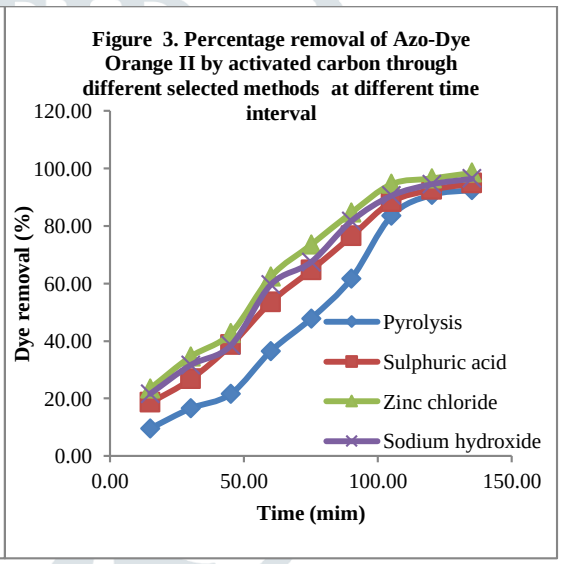

Figure 3. Percentage removal of Azo-Dye Orange II by activated carbon through different selected methods at different time interval

It is evident from the results that the removal of Victoria pure blue dye started to reach equilibrium after 2 hours for all activated carbons prepared from selected activated methods such as pyrolysis, sulphuric acid, zinc chloride and sodium hydroxide. Similar trend was observed with azo-dye Orange II dye removal from the aqueous solution.

In the case of the removal of Victoria pure blue dye, activated carbon prepared using sulphuric acid method showed maximum removal of the dye. This may be due to more pore volume created by sulphuric acid treatment. The activated carbon prepared by zinc chloride method was found to be good for the removal of azo dye when compared to other activated carbons. The contact time data showed that as the contact time increases, the rate of adsorption of dye onto the adsorbents increases initially and it becomes almost constant after optimum periods (Singh*et al*., 2017; Jamdade and Ubale, 2019).

3.3 Effect of pH

The pH factor plays an important role in the adsorption of dyes from aqueous solutions. The effect of pH was investigated using 100 ml of dye solution with 1 g of selected activated carbon adsorbent for 2 hours at

varying pH values from 2 to 10. The results found for the removal of Victoria pure blue and Azo dye Orange II dyes from aqueous solution using selected activated carbons were shown in Fig.4 and Fig 5.

Efficiency of dye removal increased with appropriate pH (Desai*et al*., 1997; Sharma *et al*., 2009). In the present study, the percentage removal of Victoria Pure Blue dye by activated carbons through different selected methods with different pH showed that activated carbon using sulphuric acid method gave maximum dye removal. The dye removal was increased from 2 to 5 and the maximum removal was found to be at pH 5. In higher pH, the dye removal was decreased (Figure 5).

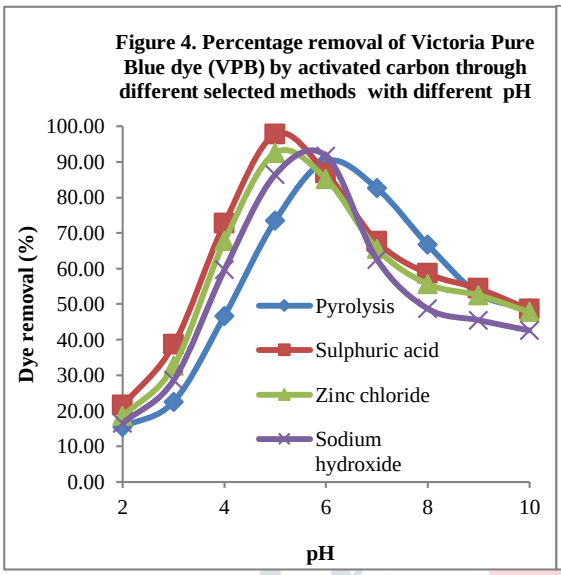

Figure 4. Percentage removal of Victoria Pure Blue dye (VPB) by activated carbon through different selected methods with different pH

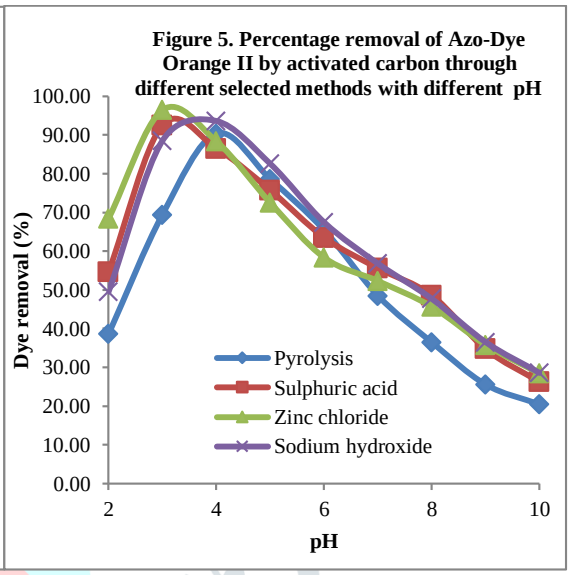

Figure 5. Percentage removal of Azo-Dye Orange II by activated carbon through different selected methods with different pH

In the case of the dye removal of by activated carbon through different selected methods with different pH showed that among all types of activated carbons, zinc chloride method adsorbent showed maximum dye removal efficiency at pH 3. However, sodium hydroxide method adsorbent was also good at pH 4 for Orange II dye removal.

3.4 Effect of adsorbent dosage

The effect of adsorbent dosage was studied using 100 ml of dye solution at pH 5 for Victoria pure blue dye removal and at pH 3 for Orange II dye removal. The dosage of adsorbents were varied from 0.1 to 1 g and were agitated for 2 hours. The results obtained that for the removal of Victoria pure blue and Azo dye Orange II dyes from aqueous solution using selected activated carbons were shown in Fig.6 and Fig 7 as shown below.

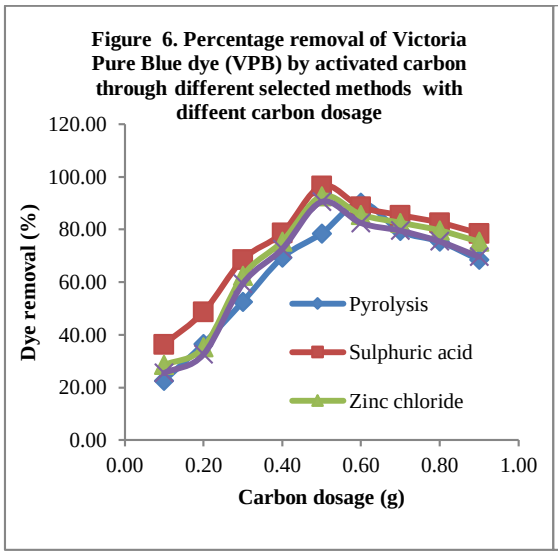

Figure 6. Percentage removal of Victoria Pure Blue dye (VPB) by activated carbon through different selected methods with diffeent carbon dosage

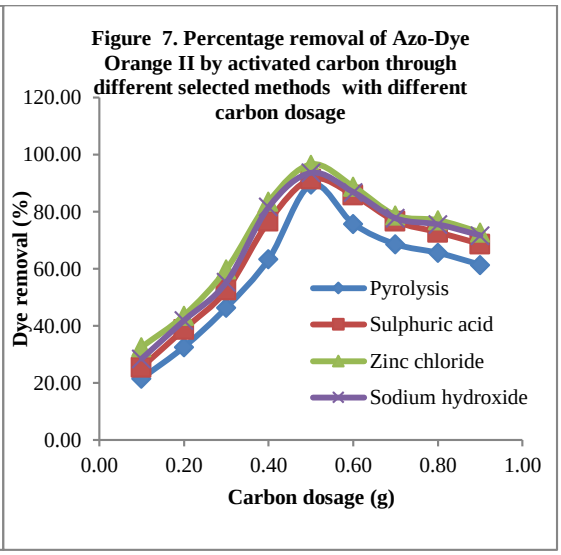

Figure 7. Percentage removal of Azo-Dye Orange II by activated carbon through different selected methods with different carbon dosage

Dye removal by adjusting the carbon dosage is also one of important factor in determining the dye removal efficacy. It was again found that activated carbon prepared by sulphuric acid treatment showed good efficiency with 0.5 g carbon dosage for Victoria pure blue dye removal. On the other hand, zinc chloride method activated carbon gave good removal efficiency with 0.5 g carbon dosage for azo dye Orange II. However, at higher concentration of carbon dosage decrease in adsorption which was due greater exchangeable sites and surface area (Ahmad, 2009; Kumar *et al*., 2017).

4.Conclusion

Peltophorum pteocarpium seed pods were used to prepare different types of activated carbons using pyrolysis, sulphuric acid, zinc chloride and sodium hydroxide methods. These activated carbons were used to study the Victoria pure blue dye and azo dye Orange II dyes removal from aqueous solutions. Batch adsorbent studies were carried out to understand the effect of contact time, pH and carbon dosage.

It was found from batch adsorption studies that activated carbon prepared by using sulphuric acid method showed good efficiency in the removal of Victoria pure blue dye from aqueous solution. On the other hand, activated carbon prepared by zinc chloride method exhibited good adsorption for azo dye Orange II from aqueous solution.

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