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Degradation analysis of Ortho-Phenylenediamine dye using natural material and UV-spectrophotometry

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Abstract

The Bentonite clays rich in montmorillonite. The removing of ortho-phenylenediamine dye (OPD) from an aqueous media by bentonite was studied. Adsorption experiments were performed by changing from different experimental parameters such as Contact time, initial dye concentration, pH, FTIR, and adsorbent dose. At pH 10 the maximum absorbance at 290 nm is 1.6718. The obtained results indicated that bentonite was able to absorb 98 %. The optimum removal conditions were observed at alkaline medium using sorbent material dose 1 g for 45 minutes and 40°C. FTIR confirmed the presence of montmorillonite unit which minimizes the toxicological properties of dyes from aqueous media. At pH 6 the maximum absorbance was 98.39 % but slowly it goes down with increase in time. Higher concentration level and high pH gives maximum absorbance.

Keywords: Bentonite; Ortho-phenylenediamine dye; Aqueous Media; Adsorption; Absorbance; Montmorillonite

1. Introduction

With increasing technologies and activities of textile industries, water pollution is continuing a critical concern problem as a result aquatic and terrestrial animals facing hazardous problems [1-2]. Dyes are broadly used in textile manufacturing industries, paper, leather and plastic for coloration of products[3-6]. These processes generate amount of water which contain high pH and chemical oxygen demand concentration. These industries utilizes 10,000 dyes and pigments[7-8]. The disposal of these colored wastewaters in the river indicated the presence and spread of organic carbons and organic contaminants such as nitrogen, dyes, sulphur, pesticides and nitrogen pollutants. Releasing such toxic dyes from industries has made a world wide worry because of their enormous toxicity towards mankind[9-10]. Dyes are mutagenic, carcinogen, gastro intestinal tract which results in nausea, vomiting, diarrhoea, harassment in the respiratory tract, skin irritation with redness and ache in case of direct contact [11-13]. Oxidation and reduction of these dyes in water can produce hazardous substances that raise the necessity of getting rid of them from wastewater [14]. Ortho-Phenylenediamine dyes is one of these contaminants that affect the quality of water [15-16]. Different technologies were used to remove organic contaminants such as chemical coagulation-flocculation, adsorption, photodegradation, biodegradation, precipitation, chemical degradation, solvent extraction and membrane technology. Recently, natural materials, which are good sorbents and inexpensive have received attention in colored wastewater treatment. Bentonite is the abundant phyllosilicate mineral, its main component is montmorillonite responsible for removal of dyes from aqueous media [17-18]. Adsorption of bentonite on the solid surface has the advantage due to its high adsorption capacity, cost-effective, flexibility, easy to handle and does not produce hazardous materials. Further, the effects of operational parameters such as solution conductivity, dye concentration, initial pH and contact time on color removal efficiency have been investigated in this study.

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2. Material and methods

2.1. Reagents and Solutions

All chemicals were of analytical grade and were used without further purification. Double distilled water was used throughout in the present work. A stock solution of ortho-phenylene diamine dye (OPD), 100 mg L-1 was prepared by dissolving 0.1g of OPD in 1000 ml of double deionized water, which was stored in Borosilicate Volumetric Glass in the dark prior for experiment. Solution of N/10 Hcl and N/10 NaOH were used to adjust the pH value of test solutions.

2.2. Apparatus and measurement procedures

The sample have been coded as O_1 – O_{23} and O_{24}- O_{46} for pH 10 and pH 6 respectively at various time intervals, shown in Table 1 and 2. Different OPD concentration such as 10 ppm, 20 ppm, 30 ppm, 40 ppm, 50 ppm 60 ppm and 100 ppm were prepared from the stock solution by dilution method in a 500 ml Borosilicate flat bottom flask. 100 ml of different dye concentration such as 10 ppm , 20 ppm, 30 ppm,40 ppm,50 ppm,60 ppm and 100 ppm OPD dye and 1 gram of bentonite, weighed by four digit analytical balance (BSM 220.4) is taken in a 250 ml Erlenmeyer flask. Now to stir the solution at a regular interval of 15 minutes by magnetic stirrer at a rate of 220 rpm at pH 4 and 10. The pH values of the solution was adjusted with NaOH and Hcl solutions. The solution were filtered by Whatman filter paper, Cat No. 1001 125 , 125 mm ø and stored in a 100 ml polythene Narrow neck reagent bottles. All absorbance measurements at its maximum absorption wavelength (290 nm) by double beam spectrophotometer, AU- 2703 Systronics. The dye concentrations were determined from their absorbance characteristics in the UV-visible range (200-600). A spectrophotometer AU 2703 connected to a personal computer through an interface and appropriate software was to control the spectrophotometer and collect and process the data in graphic form, shown in table 1 and 2.

Based on these measurements, Absorbance Vs Wavelength and decolorisation Vs time graph have been plotted to see the dye removal percentage. Basic conditions were set as follows : the initial concentration of OPD, OPD = 10 ppm , time interval, t = 15 minutes; initial solution pH, pH 6. This method was used to determine the removal of dye concentration from aqueous medium

3. Results and Discussion

3.1. Effect of initial concentration and contact time

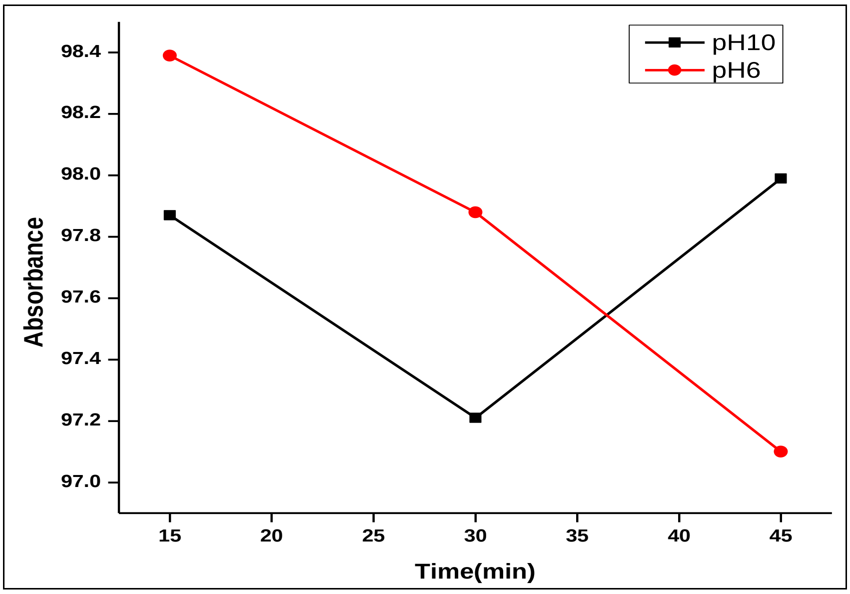

Figure 1 Effect of initial concentration and contact time

This parameter was studied in the range of 10 ppm to 100 ppm at 60 °C temperature, 1 g adsorbent mass, and time intervals of 15 minutes. From figure 1, for pH 10 it was observed that absorbance percentage decreased and after time interval of 15 minutes it increases with the increase in time. The maximum absorbance percentage of dye was recorded

97.99 % whereas at pH 6 the absorbance increased and then decreased continuously and maximum absorbance 98.39 % was recorded at 15 minutes.

3.2. Effect of Conductivity on the efficiency of color removal

Conductivity is a electrochemical technique used to characterize the purity and interaction dyes. To explore the outcome of conductivity on the efficiency of color removal and critical micelle concentration of surfactants in the presence of dyes can be seen from the figure 1. Solution conductivity is inversely proportional to the voltages as decrease in energy consumption. The maximum percentage color removal was 97.98 % at pH 10 for 45 minutes. Figure 2, depicts that high color removal percentage at high at specified cell voltage with a conductivity of 0.70 mS cm-1. From the results, rise of conductivity of dye solution has not a substantial effect on color removal.

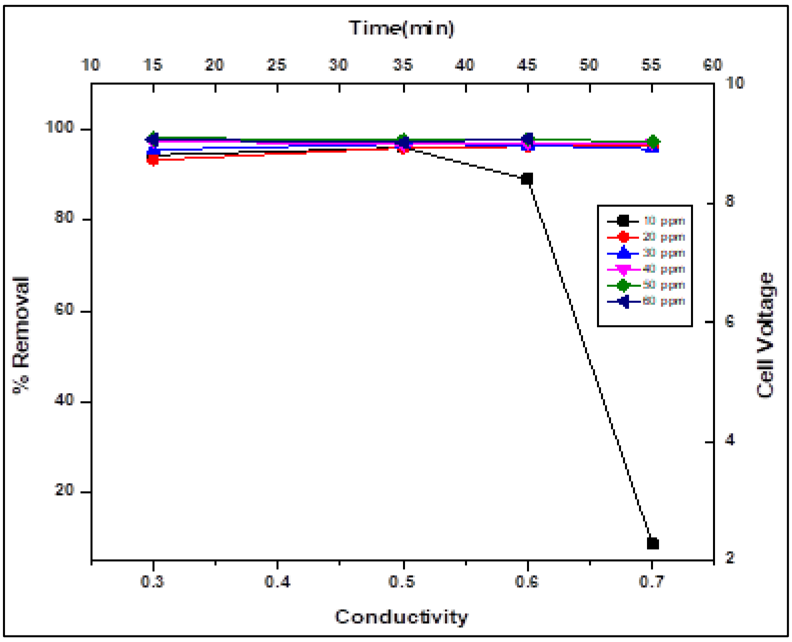

Figure 2 Effect of solution conductivity on the color removal and Cell voltage

3.3. Effect of pH on color removal

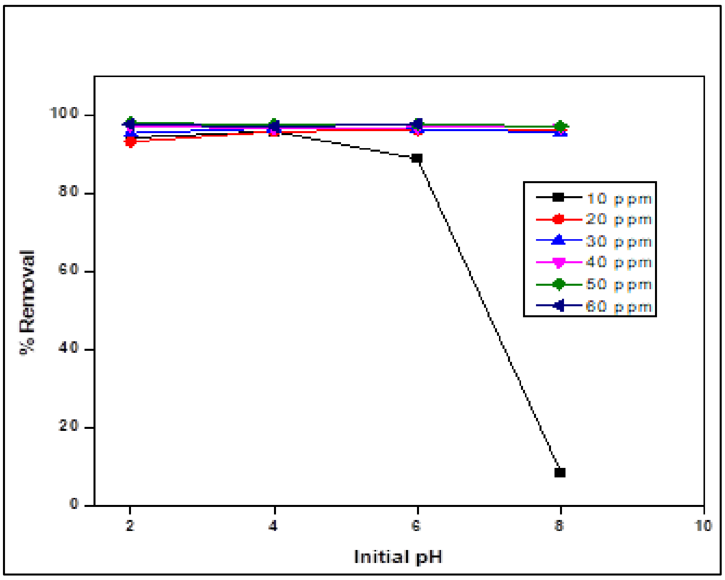

Figure 3 Effect of initial pH on the color removal at pH 10

Parameter, pH influencing the performance of electrochemical process. The pH of dye solution was adjusted by addition of N/10 Hcl and N/10 NaOH. The color removal percentage for dye solution with initial pH values of 10 and 6 were shown in figure 3 and figure 4 respectively. The results disclosed that when pH of solutions was 10, there was maximum decolorisation of dye was 97.99 % and at pH 6, maximum decolorisation of dyes was 98.39 %. The results concluded that the maximum absorbance was at pH 6.

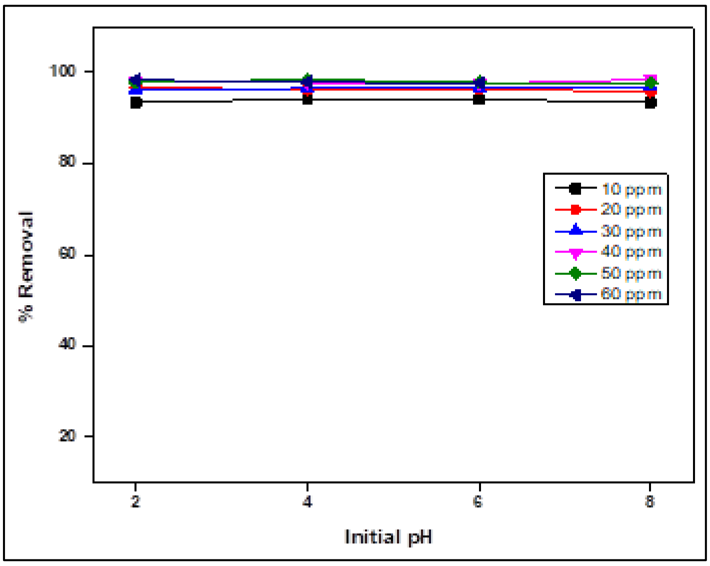

Figure 4 Effect of initial pH on the color removal at pH 6

3.4. FTIR analysis of OPD sample

Fourier transform infrared of ortho-phenylenediamine dyes(OPD) after adsorption were shown in figure 5.This analytical technique used for identify organic and inorganic materials by absorbing infrared radiation. The residue of bentonite samples have been examined by PerkinElmer IR Subtech Spectrum ASCII PEDS 4.00. From the spectra we see that due to high energy, it shows vibrations at higher frequency and force constant is maximum as well as peak is maximum. Spectra shows following peaks of O-H group, Phenol and N-H stretching in amines and amide at 3360.20 cm-1, 1780 cm-1(C= O stretching in aldehyde), 998 cm-1 represents the stretching vibration of Si-O groups. Further more, peak at 795 cm-1 indicates the presence of Fe^{3+} and Mg. It is clear that the samples is rich in Mg, Fe^{3+} and Silica.

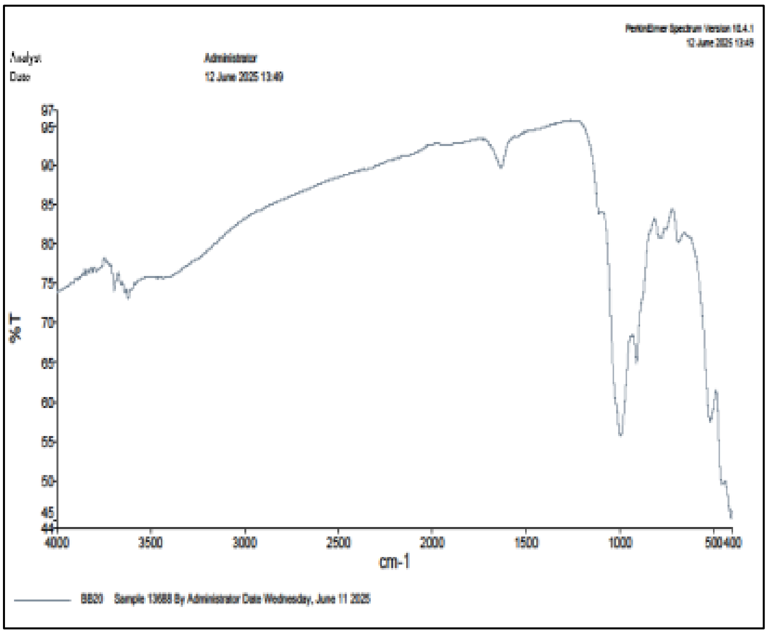

Figure 5 FTIR of OPD-Bentonite sample after adsorption

Table 1 UV Double Beam Spectroscopy data at pH 10

SAMPLE NO	290nm
O1	0.5579
O2	0.4098
O3	1.0942
O4	1.3257
O5	1.3326
O6	0.7940
O7	0.7348
O8	0.7283
O9	1.3266
O10	0.9480
O11	1.0279
O12	1.2616
O13	1.0095
O14	1.3155
O15	1.1583
O16	1.0929
O17	0.8960
O18	1.1249
O19	1.0548
O120	1.3304
O21	1.2746
O22	1.6718
O23	1.2045

Table 2 UV Double Beam Spectroscopy data at pH 6.

Sample No.	Wavelength (290nm)
O24	0.6582
O25	0.5782
O26	0.5864
O27	0.6583
O28	0.6574
O29	0.7495
O30	0.7172
O31	0.8553
O32	1.1346

O33	1.0462
O34	1.0042
O35	0.9499
O36	0.7660
O37	0.8776
O38	0.9814
O39	0.6046
O40	1.0930
O41	0.7706
O42	1.0936
O43	1.1215
O44	0.9633
O45	1.2706
O46	1.3736

4. Conclusions

This study showed that the adsorbents used in this experiment, suitable for the adsorption of OPD dye from aqueous media. UV spectrophotometric methods utilizes for the estimation of sample are cost-effective, flexibility .The effect of the different parameters was conducted at pH 6 and pH 10, adsorbent dose 1 g bentonite, contact time 15- 60 minutes, at temperature 60 °C, and initial OPD dye concentrations from 10ppm,20 ppm, 30 ppm,40 ppm, 50 ppm, and 60 ppm. The maximum dye removal percentages were 94.42, 96.32, 96.84, 96.71, 97.89, and 97.99 respectively for pH 10. FTIR results the endurance of montmorillonite unit.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict of interest to declare.

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