DYE SEPARATION TECHNIQUES FROM TEXTILE WASTE

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Abstract: **Polar solvents like Di-methyl Chloride, Chloroform and Hydrogen Peroxide have been examined for their effectiveness as dye removing agents from textile waste material. These have been subjected to varying conditions of time and temperature in the experimental analysis. Removal of dye using zinc oxide as a photo-catalyst via adsorption technique has also been carried out. Methyl orange dye has been used as adsorbate and zinc oxide as adsorbent. The effects of different particle sizes of zinc oxide and varying intensity of UV light on a constant concentration of methyl orange have been studied. Zinc oxide particles of sizes less than or equal to 3.175mm have been used. The behavior of UV light of intensity 254 nm and 365 nm has been compared.**

I. INTRODUCTION

Dyes may be defined as substances that, when applied to a substrate provide color by a process that alters, any crystal structure of the colored substances. The dyes can adhere to compatible surfaces by solution, by forming covalent bond or complexes with salts or metals, by physical adsorption or by mechanical retention. A variety of dyes are used in the textile industry to color different types of fabrics. A large amount of water is consumed by the textile industry in its manufacturing processes used mainly in dyeing. Dyes impart toxicity to the effluent and are aesthetically displeasing. Discharged waste water containing dyes reduce the conductivity of light necessary for the photosynthesis of autotrophs in water and harms ecosystems. The wastewater from textile plants is considered as a huge source of pollution, considering the volume generated as well as the effluent composition. In addition, the increased demand for textile products and its commensurate increase in production has contributed to dye wastewater becoming one of the most substantial sources of severe pollution at present. Currently, various chemical and biological methods are used for treatment of textile wastewater, but these are not cost effective. Hence a variety of adsorbents are being tested to fulfill this purpose.

Kaolinite is a 1:1 aluminosilicate consisting of stacked pairs of tetrahedral silica sheets and octahedral alumina sheets. Organic solutes adsorb to kaolinite. The strongest preference for kaolinite was shown by polyaromatic molecules carrying amino groups [5]. The adsorption of methylene blue and crystal violet on pumice powder samples of varying compositions was investigated using a batch adsorption technique. The effects of various experimental parameters, such as adsorbent dosage, initial dye concentration, and contact time, were also investigated. The extent of dye removal increased with decreased initial concentration of the dye and also increased with increased contact time and amount of adsorbent used. The adsorption experiments indicated that pumice powder was effective in removing basic dyes such as methylene blue and crystal violet from aqueous solution [4]. Simple and potentially cost-effective method of recovering indigo dye waste from the effluent through adsorption can be achieved using palygorskite clay. The recovered by-products can be converted to Maya blue, an organic–inorganic hybrid pigment with applications in the paint and coating industry. The production of a secondary commercial product from waste stream through a by-product synergy process offers an attractive alternative to discharging the untreated effluent into municipal treatment plants or the environment [3].

Orange peel is largely composed of cellulose pectin; hemi-cellulose, lignin and other low molecular weight compounds including limestone. It can be used as an efficient and cost effective bio-adsorbent for removing dyes metals and organic pollutants from industrial wastewater [2]. The removal of indigo from the textile effluent by waste pumice stone from a denim factory was studied and it was concluded that the stone has the potentialities to be used as an adsorbent for discoloration of waste water containing indigo dye [1].

Dyes can be extracted from waste fabric material using polar solvents. A solvent in which molecules have a permanent separation of positive and negative charges, or the centers of positive and negative charges do not coincide are called polar solvents. These solvents have high dielectric constants, are chemically active, and form coordinate covalent bonds. Dichloromethane, chloroform, hydrogen peroxide are some examples of polar solvents which have been used in the following experiments for removing dye from waste fabrics. Removal of dye increases with increasing time and temperature. Commercial dyes and methyl orange as a dye was used for the purpose of removal from the textile waste and wastewater respectively.

Colorimeter is a device that measures the absorbance of particular wavelengths of light by a specific solution. This device is most commonly used to determine the concentration of a known solute in a given solution by the application of the Beer-Lambert law, which states that the concentration of a solute is proportional to the absorbance.

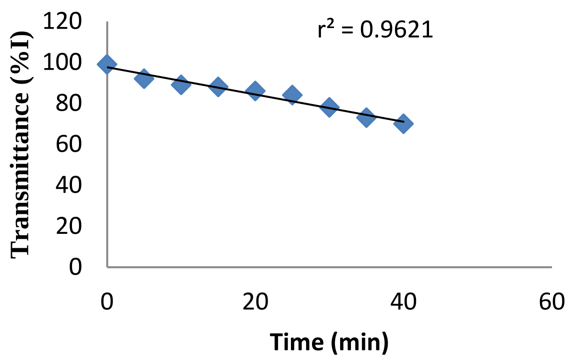

Figure1:%I as a function of time for beaker containing chloroform

Methyl Orange is a popular dye in the textile industry. Hence it forms a major portion of textile effluent which needs to be treated. Adsorption is a classical technique for treatment of textile waste. Accordingly, many porous adsorbent materials have been tested on the possibility for dye removal such as activated carbon, peat, chitin, and silica. However, intraparticle diffusion associated with porous adsorbents may reduce the adsorption rate and capacity. Consequently, there is a need to develop alternative novel adsorbents with both large surface area and small diffusion resistance characteristics. For this purpose solid zinc oxide (ZnO) has been used as an adsorbent as well as a photo-catalyst in the samples containing textile waste. Photo-catalytic reaction has been carried out by varying the wavelength of the Ultraviolet rays and varying grain size of zinc oxide. Grinding technique has been used for size reduction which is further separated using mesh analysis. The U.V. Chamber has been used for varying wavelength of U.V. rays. This study was performed to utilize zinc oxide as a low cost adsorbent.

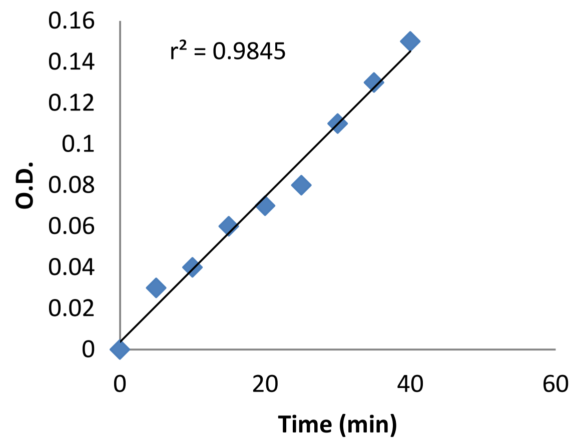

Figure 2: Optical Density as a function of time for beaker containing Chloroform

II. MATERIALS AND METHODS

A. Test: Time Dependence

The experimentation involved the removal of dye from a cloth material by using suitable solvents and observing the amount of color removed in increasing intervals of time at a constant solution temperature of 29°C. 2x2cms pieces were cut from a violet colored waste dyed cotton cloth for the experiment. These pieces were immersed in beakers containing fifteen ml dichloromethane, chloroform and hydrogen peroxide respectively. The chemicals were procured from sdfine chemicals. These three solutions were gently stirred. The color from the immersed waste cloth gradually dispersed into the solvent. Samples were taken from all the three beakers at intervals of five minutes. These samples were tested for the amount of colored dye removed in a colorimeter. Small test amounts were taken from these samples in the cuvette and placed inside the Colorimetry apparatus.

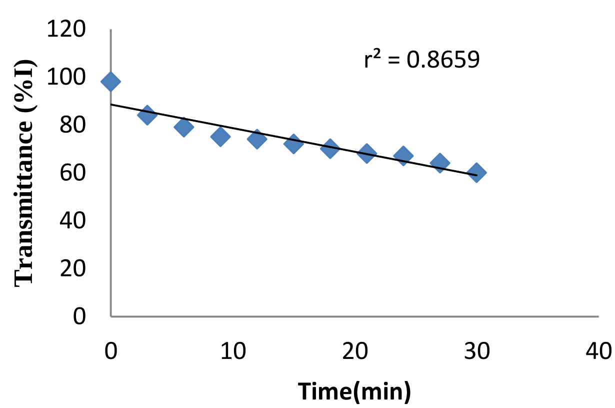

Figure 3: %I as a function of time for beaker containing Dichloromethane

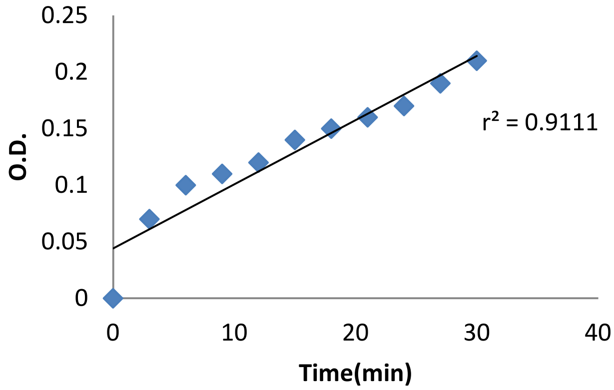

Figure 4: Optical Density as a function of time for beaker containing Dichloromethane.

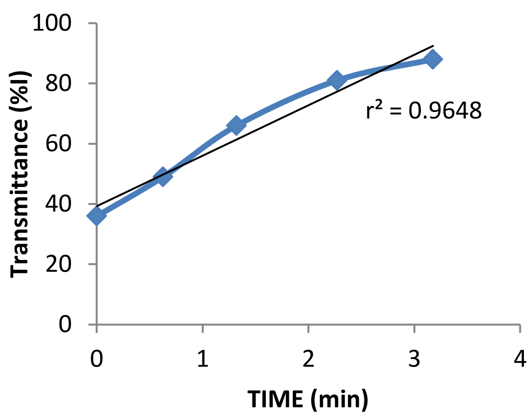

Figure 5: %I as a function of time for beaker containing Hydrogen peroxide

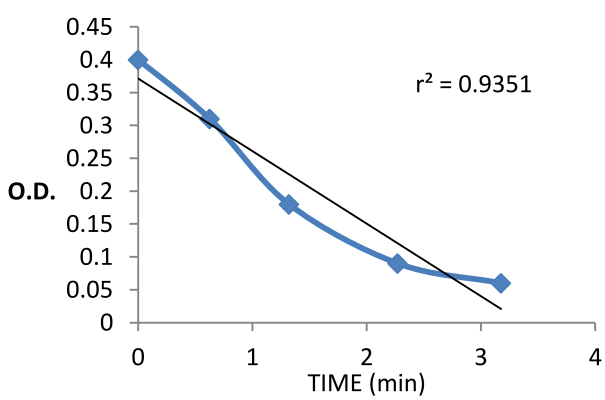

Figure 6: Optical Density as a function of time for beaker containing Hydrogen peroxide

B. Test 2: Temperature Dependence

Square pieces of 2×2 cm were cut from a violet colored waste cotton cloth and added. The experimentation involved the removal of dye from a cloth material by using dichloromethane solvents and observing the amount of color removed on increasing temperature for a constant time of one minute. Fifteen ml of Dichloromethane solution was poured into six different beakers and was kept on a heating plate. Each beaker was heated to a temperature between 30 to 40 degree celcius. It was then removed from the heater. The cloth piece was added into it for 1 minute. The solution was tested in a colorimeter.

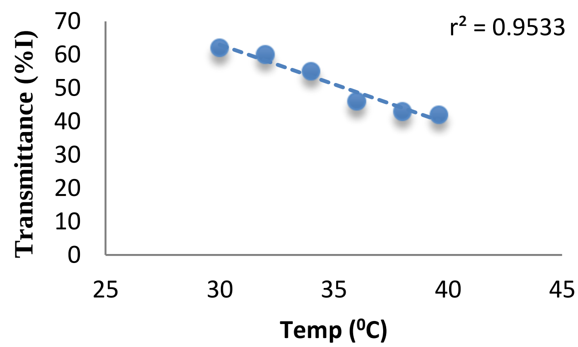

Figure 7: %I as a function of temperature for beaker containing Dichloromethane.

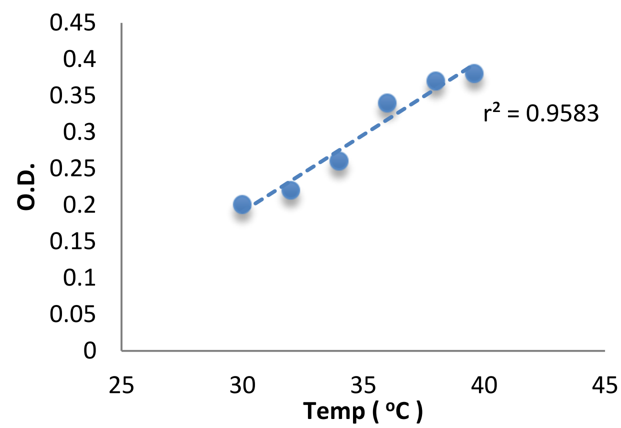

Figure 8: Optical Density as a function of temperature for beaker containing Dichloromethane.

C. Test 3: Size dependence on UV spectrum

Zinc Oxide granules of different sizes were added into beakers containing Methyl Orange and water. Time of contact between zinc oxide granules and methyl orange was kept constant for all sets of beakers. Wavelength of UV rays were kept constant during the experiment. A solution containing thirty ml water and three ml methyl orange was prepared in five beakers. Two grams zinc oxide was then added to it. This solution was subjected to UV spectrum and the solution was tested by using a colorimeter for checking amount of color adsorbed. The above procedure was repeated for varying sizes of ZnO granules.

D. Test 4: Time dependency for Ultraviolet spectrum

Zinc Oxide granules of constant size were added into beakers containing Methyl Orange and water for varying time and the amount of color adsorbed was noted. Wavelength of UV rays was kept constant. A solution containing thirty ml water and three ml methyl orange was prepared. Two grams zinc oxide was then added to it. The above granules and solution mixture was subjected to UV rays and the solution was tested by using a colorimeter for checking amount of color adsorbed as time increased.

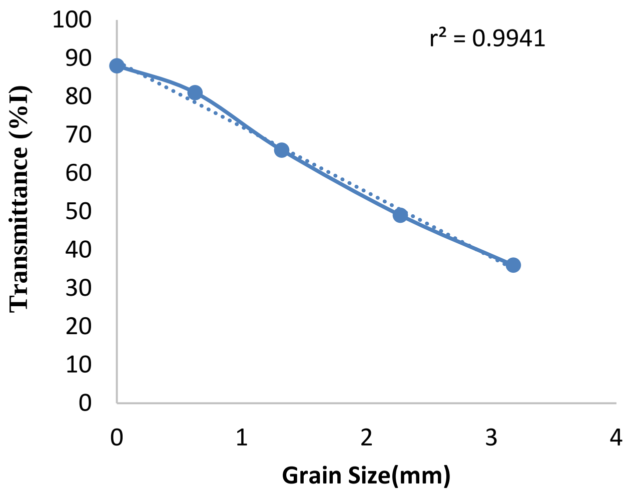

Figure 9: %I as a function of grain sizes of ZnO in a beaker containing methyl orange solution(effluent)

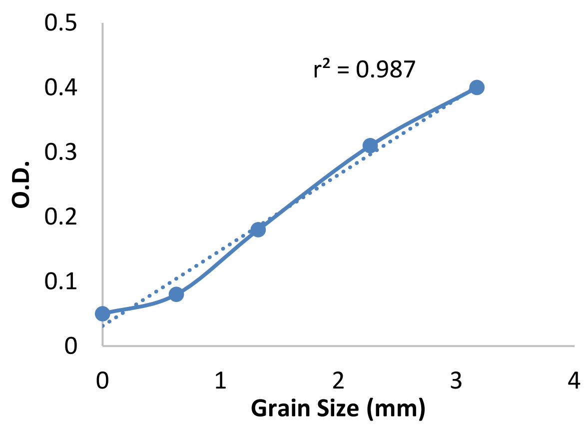

Figure 10 : Optical Density as a function of grain sizes of ZnO for beaker containing methyl orange solution(effluent).

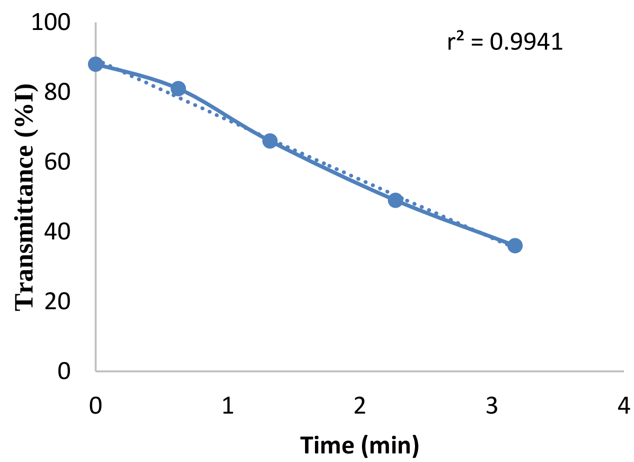

Figure 11: %I as a function of time for beaker containing methyl orange solution (effluent)

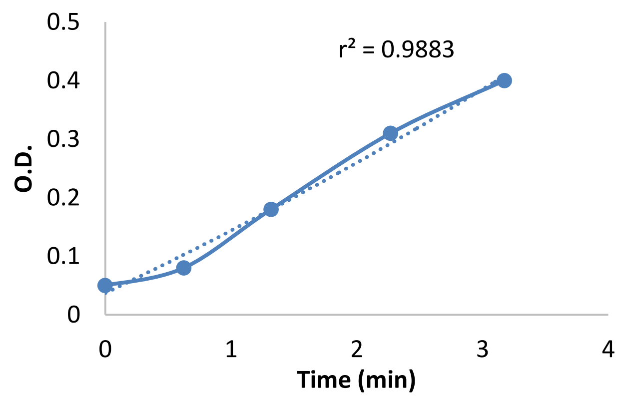

Figure 12: Optical Density as a function of time for beaker containing methyl orange solution (effluent)

E. Test 5: Varying the wavelengths

The solution of methyl orange and water was subjected to zinc oxide for adsorption in a photo-catalytic process. An Ultraviolet chamber was used for varying wavelengths :

Short UV: 254 nm
Long UV: 365 nm

Another observation was made keeping time constant for ten minutes with exposure to sunlight.

Table 1: Experimental observation of Zinc Oxide-Water-Methyl Orange solution for varying wavelength of UV light

Wavelength (nm)	%I	O.D
365	36	0.4
254	31	0.45
Sunlight	23	0.53

III. RESULTS AND DISCUSSION

Test 1 : The quantity of removal of dye increases with increase in time. A linear increase in Optical Density (O.D.) and a linear decrease in percentage Intensity (%I) of the solution is observed with increase in time. Values of correlation coefficient (r^2) are calculated and found to be close to 1 indicating the linear relationship of variables.

Test 2 : As temperature increases, the quantity of dye extracted increases. A linear increase in Optical Density (O.D.) and a linear decrease in percentage Intensity (%I) of the solution is observed with increase in temperature. Values of correlation coefficient (r^2) are calculated and found to be close to 1 indicating the linear relationship of variables .

Test 3 : As size of zinc oxide granules decreases, the quantity of dye extracted increases. A polynomial increase of degree two was observed in Optical Density (O.D.) and a polynomial decrease of degree two in percentage Intensity (%I) of the solution is observed with decrease in diameter size. Values of correlation coefficient (r^2) are calculated and found to be close to 1 indicating the degree 2 relationship of variables.

Test 4 : As time increases, the quantity of dye extracted increases. A polynomial decrease in Optical Density (O.D.) and a polynomial increase in percentage Intensity (%I) of the solution is observed with increase in time. Values of correlation coefficient (r2) are calculated and found to be close to 1 indicating the degree 2 relationship of variables .

Test 5 : As wavelength of UV light increases, the quantity of dye adsorbed increases. An increase in Optical Density (O.D.) and a decrease in percentage Intensity (%I) of the solution is observed with decrease in wavelength of UV light. Due to high scattering of UV light, a comparatively high Optical Density was obtained in the presence of sunlight.

IV. CONCLUSION

There are two types of textile wastes. One is the waste fabric material from which dye can be extracted and recycled and the other is textile effluent which is a major cause of water pollution and hence requires treatment before being released into a water body. In tests 1 and 2, waste fabric was used for extracting the dye using a suitable solvent. With increase in time and temperature, the amount of dye removed from the cloth increased in all the polar solvents used. Transmittance, which is the measure of absorbance of incident light, decreases and optical density of the solvent increases for the above mentioned scenario. Highest rate of dye extraction was observed when hydrogen peroxide was used as the solvent. Chloroform was the least effective solvent for dye removal. In the Tests 3 and 4, textile waste water was used. The Zinc oxide granules undergo a photo-catalytic process in the presence of methyl orange as the adsorbate. Low quantity of ZnO was used for adsorbing a considerable amount of dye in the waste water. The adsorbance of methyl orange on zinc oxide is observed to increase with time and temperature. To observe the changes on exposure of ZnO-Water-Methyl Orange solution to ultraviolet light of different wavelengths, test 5 was conducted. The solution was subjected to light of wavelengths 254 nm and 365 nm in the UV chamber, and sunlight having wavelength range of 100-400 nm. UV light of wavelength 365 nm was found to be most effective for the photocatalytic reaction to occur.

V. REFERENCES

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