Adsorption of Methylene Blue Dye from Water Using Methyltrioctylammonium Chloride Modified Silica Gel Under Ultrasonicator

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ABSTRACT

The effluents containing various kinds organic dyes are discharged from the industries which is a matter of an anxious feeling because these pollutants can cause serious effects on our environment and human health. In this investigation Silica gel was modified with Methyltrioctylammonium Chloride under ultrasonication and was used as an adsorbent to remove Methylene blue dye from waste water. This investigation showed that the adsorption performance of organic dye by Methyltrioctylammonium Chloride modified Silica gel was significantly improved as compare to unmodified Silica gel. The effects of dose of adsorbent, temperature and pH on adsorption of dye were studied. Characterization of adsorbent was made by FTIR and XRD. The adsorbent exhibited maximum Methylene blue dye removal efficiency at room temperature. Adsorption of Methylene blue on the I.L.-Silica gel was correlated well with the Langmuir model. The results showed that Silica gel modified by Methyltrioctylammonium Chloride was effective for the adsorption of Methylene blue dye and it is better than others because it is economic in nature and environmentally safe.

Keywords: Methyltrioctylammonium Chloride; Methylene blue removal; Adsorption; Ultrasonication; Langmuir model

I. INTRODUCTION

Textile is one of the largest water consuming and water body polluter industries that produce colored wastewater with different quantitative and qualitative chemical properties containing substantial amount of colored substances [1]. The dyes are used in some manufacturers, such as textiles, printings, cosmetics, and food dyes industries. Approximately, 50% of the dyes are released to the environment as pollutants, because of low interaction between fibers and dyes [2]. A considerable amount of Methylene blue dye wastewater is produced in the processes of the printing and dyeing industries. The dye wastewater has characteristics such as large discharge, high chromaticity, high organic matter
concentration, and poor biodegradability, and greatly affects the water body health and the photosynthesis of microorganisms in the water environment [3]. By consuming water polluted by Methylene blue dye people suffer from disease like vomiting, nausea and convulsions. The release of those colored waste waters in the ecosystem is a dramatic source of non-aesthetic pollution, eutrophication and perturbations in the aquatic life [4]. Consequently, several physical and chemical methods are undertaken to remove dyes from industrial effluents. Among the attempted methods, one can mention: adsorption, coagulation, flocculation, electrocoagulation [5–7] and photodegradation [8–9]. The adsorption technique which is based upon transfer of pollutants from the solutions to the solid phase is known as one of the efficient and general waste water treatment method [10]. Lower sensitivity to fluctuations in wastewater flow, lack of influence of toxic chemical substances on the process, high flexibility in designation and implementation, and high efficiency of organic material removal are some of the advantages of adsorption method over other common treatment processes [11]. Adsorption capacity is of great significance parameter to evaluate the adsorption effect of adsorbent. Various low-cost alternative adsorbents from agricultural solid waste, industrial solid waste, agricultural by-products and biomass are used in wastewater treatment. For example, clay [12], sludge [13], montmorillonite [14], flax fiber [15], zeolite [16,17], and biochar rice husk [18,19], pinewood [20], wheat [21], sugarcane bagasse [22], switchgrass [23], Ficus carica bast [24] as adsorbents have been used for adsorption treatment of dye wastewater. One of the major adsorbent that has been used is Silica gel. In this work, the aim of this research is to study the adsorption capacity of Methylene Blue by Methyltrioctylammonium Chloride modified Silica gel under ultrasonicator.

II. MATERIALS AND METHODS

2.1 Materials

Methylene Blue manufactured by Merck with molecular weight 319.86 g mol⁻¹, λmax 660 nm. Methyltrioctylammonium Chloride was procured from Merk. Silica gel, Toluene, HCl, NaOH was purchased from Sigma Aldrich. Methyltrioctylammonium Chloride was used after purification. Silica gel was used as such without any purification.

2.2 Preparation of Methyltrioctylammonium Chloride modified Silica gel

5gm of Silica gel was dissolve in 25 ml of conc. H₂SO₄. The solution was sonicated for 9 hrs at room temperature. Then sample washed with deionized water to remove acid from it. Then the sample was desiccate in oven at 100°C for 10 hrs. After this a suspension was made by adding Toluene in above mixture. Then 5gm of Methyltrioctylammonium Chloride was added to suspension. The mixture was sonicated for 7 hrs at 35°C. Temperature of the ultrasonicator bath was maintained by adding cold water after 20 min. After sonication the mixture was filtered and washed 2 times with ethanol and Diethyl ether, then placed in oven at 60°C for 1 hr.

1. Infrared and XRD measurement

FT-IR analysis of adsorbent was performed to determine the functional groups present in the IL-Silica gel. The FT-IR spectra of the activated Silica gel was recorded by Perkin Elmer 100 spectrometer using Potassium bromide (KBr) disc method.
Fig. 1 FTIR of Methyltrioctylammonium Chloride modified Silica

Peak at 3062.153 cm\(^{-1}\) attributed to Si-OH bond. Peak at 1463.839 cm\(^{-1}\) attributed to C=C stretching. Peaks at 1321.116 cm\(^{-1}\) and 1383.541 cm\(^{-1}\) were attributed to C-N stretch. Peak at 793.995 cm\(^{-1}\) was belong to Si-H in plane bending. Peak at 1568.845 cm\(^{-1}\) belongs to C=N stretch. Peak at 1661.970 cm\(^{-1}\) belongs to C=N stretching or O-H bending. New peaks appear at wavelength 2425.990 cm\(^{-1}\) and 1568.845cm\(^{-1}\) which confirms the modification of Silica by I.L.

We have also examined the different phases of the Silica and ionic liquid modified Silica by an X-Ray diffractometer (XRD). Comparison of both spectra was done and it was detected that at 22.5° characteristic peak of unmodified Silica appeared and from the two peaks at position 42.6° and 43.6°, crystalline phase appeared in the IL-Silica. Rest of peaks were broad indicating amorphous nature of synthesized compound.

Fig. 2 XRD OF SILICA GEL
Fig. 3 XRD OF IONIC LIQUID MODIFIED SILICA

2. Adsorption experiment

Set of adsorption experiments were conducted with Metyltrioctylammonium Chloride modified Silica gel for the removal of Methylene blue dye. Dye solution was manufactured by dissolving 26 mg Methylene blue in 1 litre water. 7g of Metyltrioctylammonium Chloride modified Silica gel was dissolved in 26 mg/l of Methylene blue solution and was sonicated in ultrasonicator at the studied reaction parameters. Temperature of ultrasonic bath was adjusted to 35°C by adding cold water after every 20 min. pH of solution was adjusted to 10 by 1 N HCl/ 1N NaOH. After the fixed period (72hrs), adsorbent solution was filtered through Whatman filter paper and filtrate was used to analyse the Methylene blue dye concentration in solution. The percentage removal of dye was compute as follows:

\[ R(\%) = \frac{C_0 - C_e}{C_0} \times 100 \]

where \( C_0 \) and \( C_e \) were the initial and final concentrations of Methylene dye (mg /l).

U.V. spectra of absorbance vs wavelength recorded for adsorption of Methylene blue dye

For substantiation the absorption efficiency of Methyltrioctylammonium Chloride modified Silica gel, U.V. spectra of both unmodified Silica gel and Methyltrioctylammonium Chloride modified Silica gel were compared. Solution of Methylene blue and water marked as sample A. Solution of Methylene blue, water and Methyltrioctylammonium Chloride modified Silica gel was marked as sample B. Sharp rise in Methylene dye solution between wavelength 400-600 nm and absorbance (4.0). After addition of adsorbent in Methylene dye solution A, we get rise at 600 nm and absorbance 1.0
III. RESULTS AND DISCUSSION

In this research work, the adsorption of Methylene blue dye on Methyltrioctylammonium Chloride modified Silica gel was investigated at various reaction conditions like dose of adsorbent, pH and temperature.

3.1 Effect of dose of adsorbent

Fig. no. 5 is the plot of removal % of Methylene blue dye against various adsorbent doses. It can be seen that removal of Methylene blue dye was 20% at adsorbent dose 10gm/l, 30% at adsorbent dose 15gm/l, 60% at adsorbent dose 25gm/l and 99.5% at adsorbent dose 35 gm/l.
3.2 Effect of pH

Fig. no. 6 is the plot of removal % age of Methylene blue dye against various pH values. It can be seen that removal of Methylene blue dye was 20% at pH 4, 30% at pH 6, 60% at pH 8 and >99% at pH 10.

![Fig. 6 The plot of removal % of Methylene blue dye against various pH values](image)

3.3 Effect of temperature

Fig. no. 7 is the plot of removal % age of Methylene blue dye against different values of temperature. Adsorption was 20% at 20°C temperature, it was 30% at 25°C temperature, 60% at 30°C and >99% at 35°C.

![Fig. 7 The plot of % removal of Methylene blue dye against different values of temperature](image)
Equilibrium modelling

Langmuir isotherm

Assumption of Langmuir isotherm is that the surface of the adsorbent is homogeneous, the adsorption energy is constant over all sites and each site can accommodate only one molecule or atom. The Langmuir adsorption isotherm is given as [25]:

\[ q_e = q_{\text{max}} \frac{b C_e}{1 + b C_e} \]

where \( q_{\text{max}} \) (mg/g) and \( b \) (dm\(^3\)/mg) are Langmuir constants associated with the capacity and energy of adsorption.

![Fig. 8 Langmuir adsorption isotherm](image)

CONCLUSION

A novel Methyltrioctylammonium Chloride activated Silica was prepared under ultrasonication for the removal of Methylene blue dye from waste water. Different reaction parameters were studied. >99% Methylene blue dye was removed by using IL-Silica under ultrasonication. The overall results showed that IL-Silica has a promising potential for removal of Methylene blue dye from water. Therefore it is economic and novel adsorbent for adsorption of dye from water.

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REFERENCES


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