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Treatment of Textile/Dye Wastewater by Adsorption Using Metal Oxide Nano Particles

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Abstract: Textile industries produce large amounts of waste water. Presence of various dyes like reactive dyes, azo dyes, anthraquinone dyes, etc.is noted in textile industry effluent. In this work we intend to target azo dyes and anthraquinone dyes which has various colouring and toxic effects. Literature review shows that there are various sustainable wastewater treatments namely adsorption, electro-coagulation, ultrasonic treatment, etc. The present investigation intends to discuss the adsorption method for the treatment of industrial wastewater using metal oxide nanoparticles. Literature review supports the use of synthesized porous MgO powder at Nanoscale for the removal of dyes from aqueous solution. Results indicate that the MgO powder can remove more than 98% of both dyes under optimum operational conditions. At various MgO dosages, dye concentrations, solution pH and contact time in a batch reactor are studied. The analysis is followed by FTIR & XRD.
Keyword: Waste-water, MgO, Nano particle, Adsorption, Congo red

I. INTRODUCTION

All over the world contamination of water resources is mainly due to increase in urbanization and industrialization. Among these pollutants, significant quantities of Synthetic dyes contribute a lot in water pollution. In textile industry wet processes like bleaching, printing and dyeing consume large volumes of water and chemicals in textile industry. Unfixed dyes from rinsing operation and spent dye bath both make wastewater extremely colored. Nearly 20-50 % of dye remains free and is discharged into wastewater. These dyes negatively affect the aesthetical value of water bodies and cause annoyance to the aquatic life by affecting penetration of sunlight which ultimately reduces the photosynthetic Activity and inhibit the development of aquatic flora and fauna [1].

Approximately one million tons of these dyes are manufactured per annum around the world. Nanotechnology is an emerging technology of 21st century. These nanoparticles present considerable advances in wastewater treatment with their significantly high surface area along with their sorption sites, specific pore size, small intraparticle distance and their surface chemistry. In present study, Reactive Black 5 (RB5) and Reactive Orange 122 (RO122) were selected to analyze the behavior of adsorption.RB5 and RO122 both are azo dyes. Massive amounts of reactive azo dyes are consumed in textile sector for cotton and wool dyeing due to their cost and color variety but the main problem associated with their usage is the fixing Ability to the fabric. Nearly 50% of these dyes remain unfixed due to inefficiency in industrial processing [1].

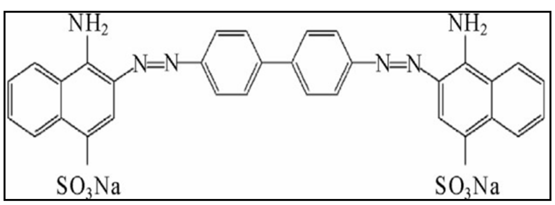

Fig.1: Molecular structure of Congo Red Dye [1]

II. MATERIALS AND METHODS

Congo red ($C_{33}H_{22}N_6Na_2O_6S_2$), it is an azo dye having molecular weight 696.65 g/mol. It is water- soluble, yielding a red colloidal solution; its solubility is greater in organic solvents. It has carcinogenic properties. Here, surface properties of MgO (*Magnesium Oxide*) nanoparticles has been used for adsorption of dye from wastewater. MgO nanoparticles has been synthesized using Solgel technique.[1]

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III. EXPERIMENTAL WORK

A. Synthesis of Adsorbent

Co-precipitation method was adopted for the synthesis of MgO nanoparticles. 100g of hydrated magnesium chloride ($MgCl_2.6H_2O$) was dissolved in 500ml distilled deionized water and 50ml of 1 N solution of NaOH was taken in separating funnel and added drop-wise into $MgCl_2$ solution with continuous stirring with the use of magnetic stirrer. After dropping, the precipitates were filtered along with gentle washing. The solution form was centrifuged at 3500 rpm for 5 min of so as to form gel. Then precipitates of MgO were dried in oven at 65°C for 3-4 hours and then placed in muffle furnace at 480°C for 3-4 hours. White colored powdered MgO nanoparticles were prepared [2].

B. Batch Study

Batch experiments were performed to evaluate the effect of different parameters on adsorption process. Predetermined dye solutions were taken in conical flasks and measured amounts of the adsorbent were added into it. All the conditions were kept constant in each experiment except for the one which was under examination [2].

IV. RESULTS AND DISCUSSION

A. XRD Analysis

X-ray diffraction technique was used to study the crystalline nature of MgO nanoparticles. The results of crystallographic parameters showed cubic crystalline structure of MgO nanoparticles with crystalline size of 19 nm and measured density of 4.21 g/cm3. Fig. 2 showed XRD peak pattern of MgO nanoparticles and XRD reference pattern of MgO nanoparticles respectively. XRD pattern of MgO nanoparticles was taken at position 2θ ranging from 10°-80°. The resultant pattern showed five characteristic peaks at 2θ value were located at 36.932°,42.906°,62.294°, 74.675° and 78.614° corresponding to 111, 200, 220, 311 and 222 crystal planes indicating the formation of cubic structure of Mg-O. The XRD data revealed that the synthesized MgO nanoparticles are similar to the cubic structure with the space group (Fm-3m) [10, 8].

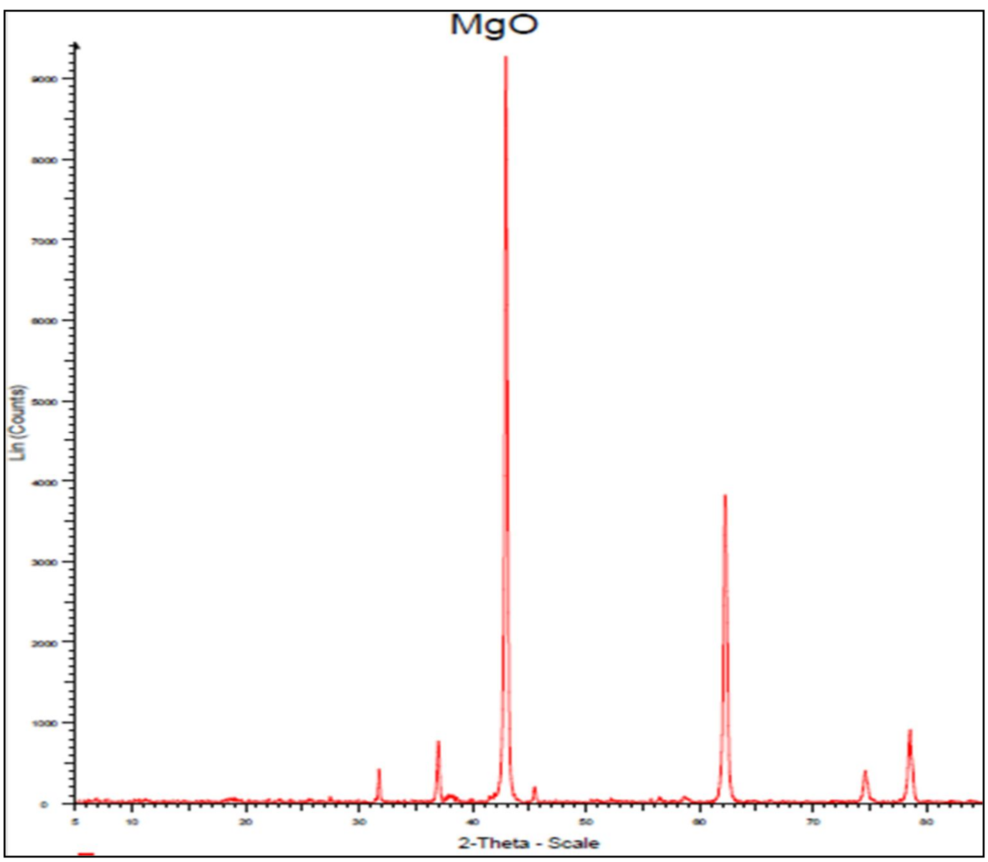

Fig.2: XRD peak pattern of MgO nanoparticles

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B. Effect of pH

Effect of pH was studied for the range of 2-12 pH. Optimized values of shaking speed, time and adsorbent dose were set at room temperature. Fig.3 shows primarily, it was observed that at pH 2 the sample showed absorption at around 579 nm. Whereas, the absorption maxima observed for all other pH solutions was around 506 nm. Also, as the pH increases from 4 to 7, the absorptivity was found to increase and after that it decreased.

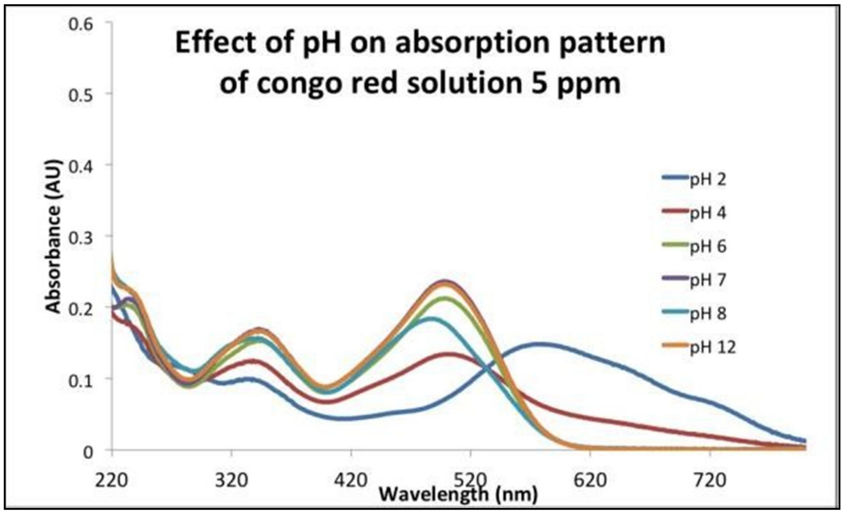

Fig.3: Effect of pH on absorption pattern of Congo red solution 5 ppm (pH:2,4,6,7,8,12)

C. Thermodynamic Parameters

Thermodynamic parameters were calculated from the experimental data of dye over a range of 293- 303 K with all other parameters set at optimum conditions. Three different parameters i.e. Gibbs free energy, enthalpy and entropy change were calculated by plotting graph between inverse of T and lnK [3]

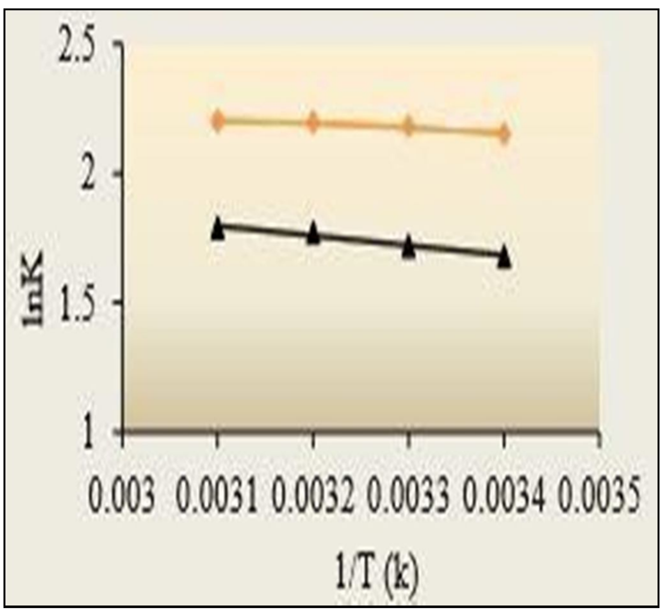

Fig.4: lnK vs 1/T [3]

V. CONCLUSION

The effective removal of dye concentration by adsorption was noted. The synthesized MgO Nano- crystallites were effective in removal of dye from the aqueous solution. More than 87% of dye removal with MgO dosage of 0.4 g was observed. The adsorption of dye depends on pH of the solution. The maximum removal efficiency was noted at pH 2.

9

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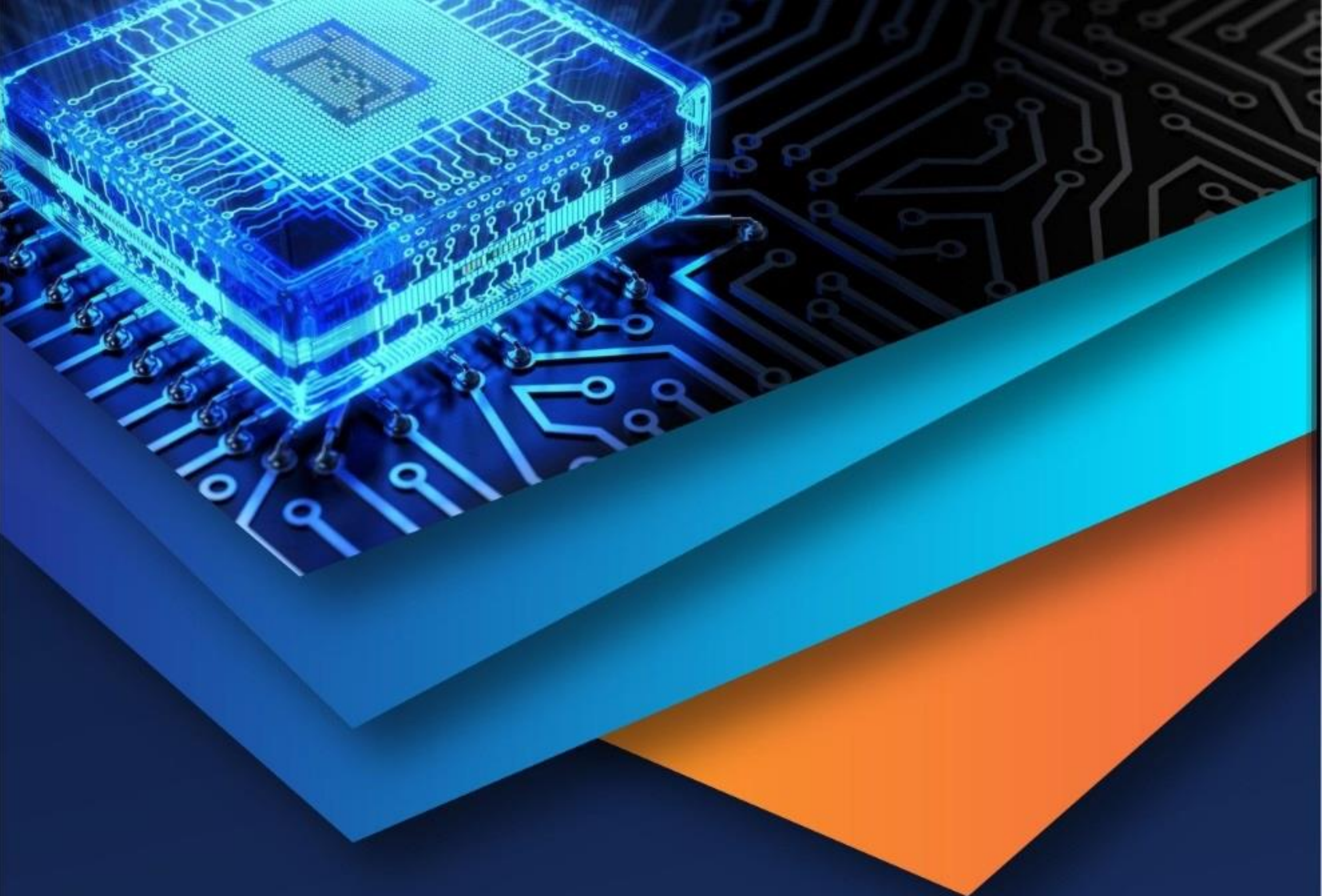

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