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BATCH STUDIES ON COLOUR REMOVAL POTENTIAL BY ZINC OXIDE NANOPARTICLES

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Abstract - *The presence of color and the color causing compounds has been always undesirable in water bodies which is either used for domestic or industrial need. Many industries like textile mill, cosmetics, food processing, dyeing industries, slaughter house discharges colored wastewater in to water bodies which causes introduction of toxic chemicals in the streams and river. This pollutant is harm full to aquatic organisms, aquatic flora and fauna and also harmful for human beings also leads to change in ecosystem. Till the day many approches have been developed to deal with dye contaminants in wastewater, which includes adsorption, reverse osmosis, flocculation, coagulation, electrolysis,biodegradation and photocatalytic degradation. Among the mentioned techniques adsorption is considered to be promising strategy due to its high efficiency, economicfeasibility and simplicity in operation. Adsorption of dye waste by using nanoparticles is one of the promising and advance technique for color removal. Thus in this present work adsorption of synthetic dye samples has been tried by using Zinc oxide Nanoparticle (ZnO NPs) for the dye Reactive Black 8 (RB 8) and Direct Red 23 (DR 23). The adsorption studies were carried out under varied experimental condition like pH, Initial Color Concentration, Adsorbent Dosage and contact time. Removal of Reactive Black 8 from ZnO NPs was found to have higher decolorization efficiency in alkaline condition of pH 9 obtained 99.6 % and got reduced with the decrease of pH to 5 and the efficiency was found to obtain 18.2 % respectively. Decolorization of Direct Red 23 by ZnO NPs was found to have higher color removal efficiency in acidic condition of pH 5 and was 98.5 % and got reduced with increase in pH to 9 of about 25.3 % .*

***Key Words*:** Adsorption, Dyes, Reactive Black 8 (RB 8), Direct Red 23 (DR 23), Zinc Oxide Nanoparticles (ZnO NPs)

1. INTRODUCTION

Due to increase in industrialization and urbanization contamination of water resource has been increased due to discharging of wastewater directly in to water without proper treatment [1]. Colored organic effluent produced in almost all industries such as textiles, rubber, paper, plastic, cosmetics, etc [2]. Discharge of dyes into wastewaters from coloring industries (particularly the textile industry) is one of the major environmental problems, because it does not only damage the aesthetic natures of the contaminated water, but also disturbs aquatic communities present in the ecosystem by obstructing light penetration and oxygen transfer into water bodies[4] creates harmful effect to both human health and environment. Pollutant presence block the passage of sunlight through water, hiders photosynthesis and affect aquatic flora and fauna [3]. Therefore adequate treatment should be given to effluent before discharging to water bodies. Several physical, chemical and biological methods have been adopted to remove complex dye structure [2]. Several synthetic and natural materials such as clay, activated carbon, polymers, zeolite, and agricultural waste have been developed as adsorbents for treatment of the contaminated water. To develop economic and effective adsorbent material, in recent years, nanostructured materials have attracted extensive attention for adsorption processes because of their high surface area, providing fast kinetics and more efficiency in color removal technology [4]. In depth literature survey has been carried out to understand the various colour removal by different nanoadsorbents. Based on these studies, it was planned to carryout batch experimentation setup for colour removal by nanoparticles with different experimental parameters considered. Thus in this present study attempt has been made to evaluate the adsorption potential of Zinc oxide nanoparticles in decolorization of Direct Red 23 and Reactive Black 8 from synthetic samples.

1.1 Objectives

The specific objectives of present works includes

1. Nanoparticle selection and its synthesis.

2. To fabricate bench scale setup [Batch studies] to be used for experimentation.

3. To select dyes for experimentation.

4. To prepare synthetic coloured samples.

5. To evaluate treatment potential of synthetic coloured wastewater samples by nanoparticles under varied experimental conditions.[Adsorbent dosage, pH, Contact time and initial colour concentration]

6. To arrive at maximum colours adsorption potential of nanoparticles.

2. MATERIALS AND METHODOLOGY

2.1 Adsorbent used and its Preparation:

Preparation of Zinc Oxide Nanoparticles by Aqueous Solution Method;

1. Zinc acetate of 2.1 g dissolved in double distilled water of 200 ml.

2. After 10 minutes of stirring about 1.5 g of tri-sodium citrate mixed in 10 ml water and

4.2 ml of 25 % ammonia solution were added.

3.Next, 2M NaOH solution of 20 ml added drop wise with vigorous stirring.

4. Temperature of contents raised to 80^0 C and kept at this temperature for 6 hours. Then contents centrifuged and precipitate washed five times in distilled water and dried at 60^0 C and thoroughly ground [5].

Picturious views of Adsorbent is given in Plate 1

Plate 1: Synthesized Zinc oxide Nanoparticle

2.2 Selection of Color and Preparation of Samples

For the color removal process in this present study the selected dyes were

- Direct Red 23
- Reactive black 8.

Color Stock solution (1000 mg/L) produced by dissolving a measured quantity of Reactive black-8 and Direct red-23 in distilled water. All working solutions prepared by diluting required quantity of stock solution in 1000 ml of distilled water (10 mg/L, 20 mg/ L, 30 mg/ L,40 mg/ L). To adjust pH of the solutions Sodium Hydroxide (NaOH) and Hydrochloric acid (HCL) of 2N solution were added.

2.3 Experimental Procedure

For experimentation Jar test Apparatus has been used. (Batch Studies)

1. For the performance of jar test initially four cleaned beakers of 1000 ml capacity has been taken.

2. In those beakers the color solutions of known quantity were taken and pH was adjusted.

3. Then to each beaker pre fixed quantity of adsorbents were added and agitated at 100 rpm

4. To evaluate the influence of stirring time on removal efficiency, the samples were stirred for various contact times. After these time intervals samples were collected and were analyzed by spectrophotometer with specified wavelength for color removal efficiency.

2.4 Parameters Considered

Bird view of parameters considered for experimentation is presented in table 1

Table 1: Parameters Considered for Experimentation.

Sl. No	Parameters	Values
1	pH	5,7 and 9
2	Adsorbent Dosage	200, 300 and 400 mg
3	Initial Colour Concentration	10, 20, 30 and 40 mg/L
4	Contact Time	20, 40, 60 and 80 min

2.5 Analysis of Samples

The intensity of colors before and after adsorption process were measured using spectrophotometer by calibrating and adjusting the spectrophotometer for the wavelength 400 nm and 500 nm for the color considered Reactive Black-8 and Direct Red-23 respectively. From the calibration curve prepared, the color intensities after adsorption were measured based on percentage adsorption results recorded from spectrophotometer.

3. RESULTS AND DISCUSSIONS

Findings of experimentation carried out to evaluate the removal potential of Zinc oxide nanoaprticles in removing Reactive Black 8 and Direct Red 23 under varied experimental conditions pH, Adsorbent dosage, Contact time, Initial colour concentration are presented in table 1 and 2 and Fig. 1 to 6 based on the experimental observation discussions were made and thereby inferences were drawn.

Table 1: Experimental Finding with Adsorbent ZnO NPs and Colour Reactive Black 8 at pH 9

Adsorbent Dosage, mg	Contact Time, min	Effluent Colour Concentration at Stated Initial Colour Concentration, mg/L			
		10	20	30	40
200	20	4.18	9.1	15.66	24.32
	40	2.74	7.72	14.31	21.16
	60	1.45	5.14	9.54	15.04
	80	1.66	5.74	10.30	15.88
300	20	3.58	8.1	14.19	22.32
	40	2.39	6.74	12.75	18.74
	60	0.98	4.12	7.59	12.68
	80	1.16	4.98	8.52	13.72
400	20	1.91	4.72	8.25	14.16
	40	1.18	3.16	6.33	11.96
	60	0.04	1.28	4.11	9.92
	80	0.39	1.68	4.71	10.52

Table 2: Experimental Finding with Adsorbent ZnO NPs and Colour Direct Red 23 at pH 5

Adsorbent Dosage, mg	Contact Time, min	Effluent Colour Concentration at Stated Initial Colour Concentration, mg/L			
		10	20	30	40
200	20	3.16	7.68	13.44	20.2
	40	2.28	6.12	11.25	16.68
	60	1.67	4.66	8.88	13.56
	80	1.53	4.34	8.64	13.24
300	20	2.49	6.12	10.92	17.04
	40	1.66	4.28	8.58	13.92
	60	1.05	3.34	6.99	11.16
	80	0.81	3.16	6.51	10.60
400	20	1.57	4.24	8.31	13.76
	40	0.96	2.86	6.54	11.44
	60	0.34	1.72	4.02	8.08
	80	0.15	1.5	3.54	7.04

3.1 Effect of pH

Removal of RB 8 and DR 23 by ZnONPs was conducted at varying pH of 5, 7 and 9. Better results obtained for decolorization of Reactive black 8 as pH increased from 5 to 9 and for Direct red 23 removal efficiency got increased as pH decreased from 9 to 5.

3.2 Effect of Initial Concentration

The lower and higher removal efficiency recorded at 10 and 40 mg/L respectively indicated that removal efficiency is a function of concentration of colour and is directly proportional.

3.3 Effect of Contact Time

To evaluate optimum time for maximum adsorption of RB 8 dye and DR 23 on ZnO NPs, time varied from 20 to 80 minutes. The maximum colour removal efficiency for RB 8 was observed at 60 min above this a slight decrease in efficiency recorded, whereas for Direct red 23 removal it was observed as contact time increased the removal efficiency got increased.

3.4 Effect of Adsorbent Dosage

Linear relationship between dosage and colour removal has been obtained. It was observed as adsorbent dosage increased from 200 mg to 400 mg the removal efficiency also found to be increase.

For Reactive Black 8 maximum [Adsorbent dosage 400 mg, pH 9, Co= 10 mg/L, Contact time t =60 min] and minimum [Adsorbent dosage 200 mg, pH 5, Co= 40 mg/L, Contact time t =20 min] removal efficiency recorded were found to be 99.6 % and 18.2 % respectively.

For Direct red 23 maximum [Adsorbent dosage 400 mg, pH 5, Co= 10 mg/L, Contact time t =80 min] and minimum [Adsorbent dosage 200 mg, pH 9, Co= 40 mg/L, Contact time t =20 min] removal efficiency recorded were found to be 98.5 % and 25.3 % respectively.

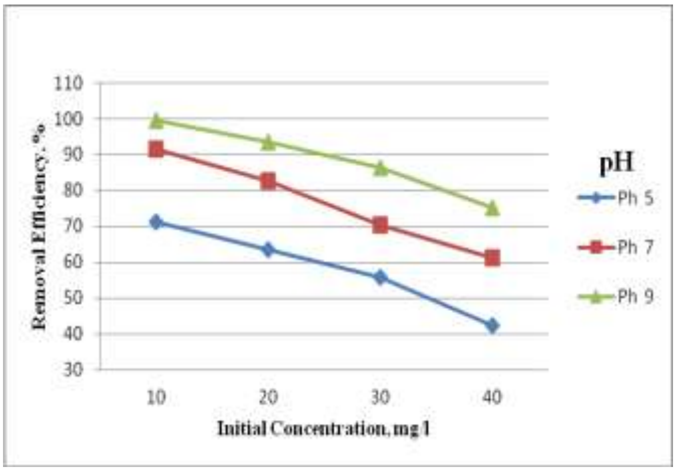

Fig. 1 Effect of Initial Concentration on RB 8 with ZnO NPs (Dosage 400 mg, t= 60 min)

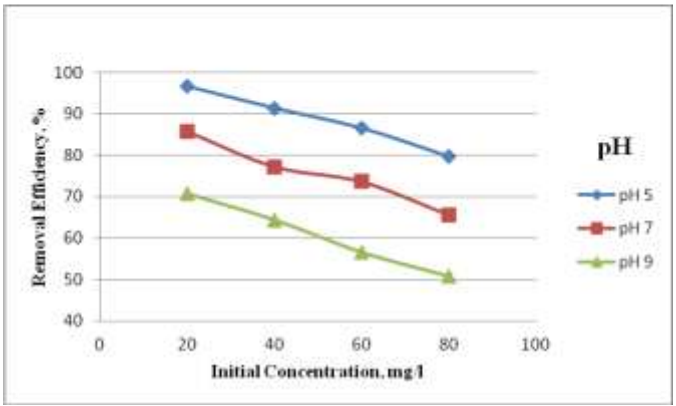

Fig. 2 Effect of Initial Concentration on DR 23 with ZnO NPs (Dosage 400 mg, t= 80 min)

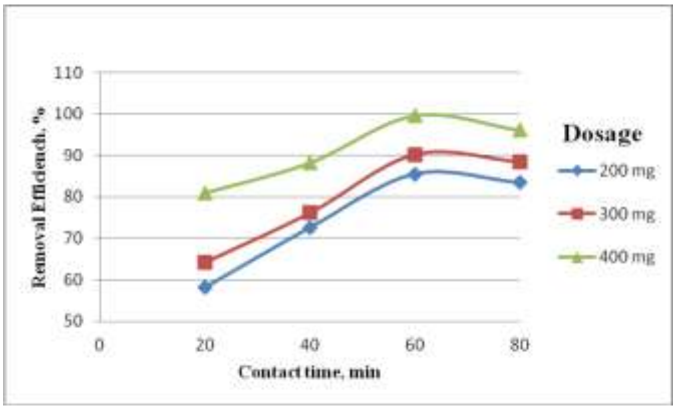

Fig. 3 Effect of Contact time on RB 8 at pH 9 (Co=10 mg/L, ZnO NPs)

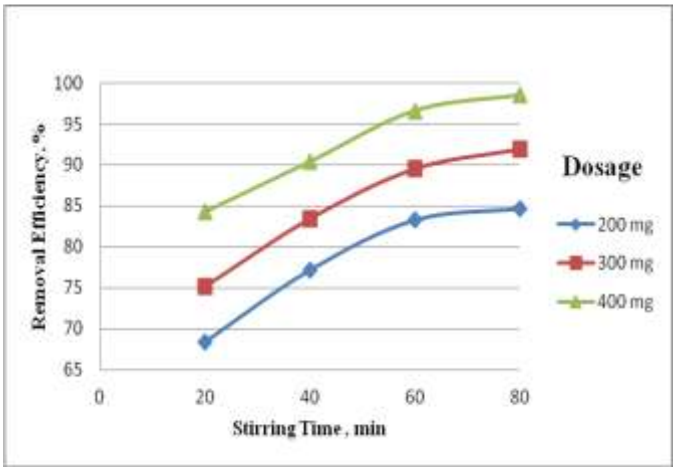

Fig. 4 Effect of Contact time on DR 23 at pH 5 (Co=10 mg/L, ZnO NPs)

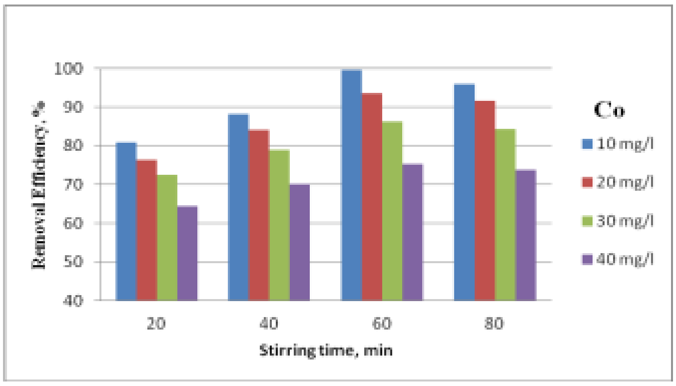

Fig. 5 Effect of ZnO NPs on removal of RB 8 at pH 9 (Dosage 400 mg)

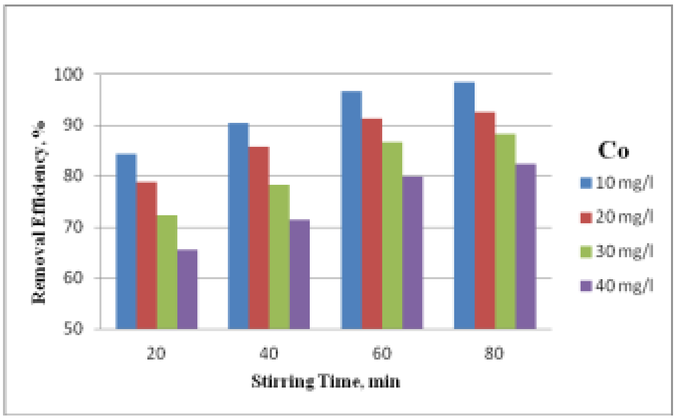

Fig. 6 Effect of ZnO NPs on removal of DR 23 at pH 5 (Dosage 400 mg)

4. CONCLUSIONS

Based on the performance evaluation of the present work, the following conclusions have been drawn.

1. It is concluded that maximum removal efficiency of Direct dye occurs in acidic pH range of 5, and high colour removal efficiency of reactive dye occurs in alkaline pH range of 9.

2. It can be concluded that as initial concentration increased the removal efficiency of both colour decreased.

3. As the adsorbent dosage increases the decolorization efficiency was found to be increased.

4. It is concluded as contact time increased the removal efficiency of reactive black 8 by ZnONP up to 60 min above which efficiency decreased, for direct red 23 colour removal by ZnO NP the removal efficiency increased with contact time.

5. From the results it can be concluded as ZnONPs can better remove Reactive black 8 compare to Direct red 23 under optimum condition of variables considered for

study. However within a statistical limitations the comparision of removal efficiencies of these two colour by ZnO NPs is found to have no significance [less than 5 % variation]

6. Maximum removal of RB 8 and DR 23 by ZnONPs was observed to be 99.6 % and 98.5 % respectively and minimum colour removal efficiency obtained as 18.2 % and 25.3 % respectively.

4.1 Limitations of Present Study

Generally textile industry effluent will be containing mixed colours and of various concentrations, therefore in practicsl sense potential of adsorbent in treating actual effluent is to be studied for optimum conditions.

The studies were carried out for selected range of variables, conclusions and inferences are drawn considering the best out these variables. However the refined optimization of variables experimentation is the limitation in present setup.

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