



AN INVESTIGATION ON WATER QUALITY PARAMETERS IN TEXTILE INDUSTRY EFFLUENT BY USING ZINC ALUMINIUM CARBONATE LAYERED DOUBLE HYDROXIDE (ZAC-LDH) AND CALCINED ZINC ALUMINIUM LAYERED DOUBLE HYDROXIDE (CZA-LDH)

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ABSTRACT

In the present study, Zinc Aluminium Carbonate Layered Double Hydroxide (ZAC-LDH) was synthesized by co-precipitation followed by hydrothermal method using CTAB as a soft template. Synthesized ZAC-LDH and its calcined sample CZA-LDH were characterized by XRD and SEM. The five different textile dye effluents were collected from different dyeing industries located in Sipcot, Perundurai and batch mode experiments were adopted out with the synthesized ZAC-LDH and CZA-LDH for the removal of colour present in effluent samples. Water quality parameters were also investigated by using ZAC-LDH and CZA-LDH before and after the adsorption process. The percentage of chemical oxygen demand (COD) removal by ZAC-LDH was observed as 71.83% for 2nd effluent sample and 77.46% for 5th effluent sample. Similarly for CZA-LDH, the COD removal was observed as 76.71% for 2nd effluent sample and 84.46% for 4th effluent sample. There was also an appreciable decrease in other water quality parameters in the effluents. From the results, it revealed that both the material ZAC-LDH and CZA-LDH were used as efficient material for the treatment of textile industry effluent.

Keywords: Chemical Oxygen Demand, Color Removal, Co-Precipitation, Textile Effluent, Zinc Aluminium Layered Double Hydroxide

1. INTRODUCTION



Water is an essential commodity for our life. Due to overwhelming industrialization and development in current scenario, every day we are in a condition to use more volume of water and also discharge wastewater into unused land or otherwise nearby water stream. Thus the water contamination due to organic, inorganic and biological pollutants may pose a serious environmental issue. Some of the pollutants released by dyeing industries are non-biodegradable and carcinogenic in nature. Even a trace quantity of colour in wastewater reduces the photosynthetic activity in aquatic ecosystem by depleting the dissolved oxygen [1-3]. Adsorption study was not only used for colour removal, but also for the treatment of other water quality parameters like pH, turbidity, conductivity, hardness, chloride, sulphate, alkalinity, BOD and COD.

Various methods have been employed for the removal of colour and other water quality parameters in real effluent from textile industry. Indeed adsorption is an efficient method for wastewater treatment using wide variety of adsorbents like activated carbon, chitosan, fly ash and natural clay etc. In addition to color removal, COD removal was also essential since COD value is the main key for indicator of water purity. Many researchers have attempted for treatment of COD [4,5] and BOD [6] using adsorption phenomenon in wastewater treatment. Besides Layered double hydroxide attracts an interest towards effluent treatment in addition to color removal from textile dye industrial wastewater.

The Layered Double Hydroxide has the general formula of $[M^{2+}_{1-x}M^{3+}_x(OH)_2]^{x+}(A^{n-})_{x/n} \cdot mH_2O$, where M^{2+} is divalent metal (Zn^{2+} , Mg^{2+} , Fe^{2+} etc), M^{3+} is trivalent metal (Al^{3+} , Fe^{3+} etc), A^{n-} is interlayer anions (CO_3^{2-} , Cl^- , NO_3^- , SO_4^{2-} etc.), [7,8], x is the ratio of $M^{2+}/(M^{2+} + M^{3+})$ and m is the number of moles of water [9,10]. Upon thermal treatment, LDH materials lead to the formation of mixed metal oxides with loss of interlayer anion and water molecule. Applicability of original LDH and its calcined products in various fields such as ion exchange process, photocatalysis, catalyst support and adsorption in wastewater treatment process [11-15].

In the present study, the synthesized Zinc Aluminium Carbonate Layered double hydroxide (ZAC-LDH) and its calcined product (CZA-LDH) material using screened for the suitability of these materials for the treatment of real dye house effluent.

II EXPERIMENTAL

2.1. Preparation of Zinc aluminium carbonate Layered Double Hydroxide (ZAC-LDH) and CZA-LDH

Zinc Aluminium carbonate layered double hydroxide (ZAC-LDH) was synthesized by using aqueous solution of $ZnSO_4 \cdot 7H_2O$ and $Al_2(SO_4)_3 \cdot 16H_2O$ in the molar ratio $M^{2+}/M^{3+}=3$. Exactly 0.3g of the CTAB was added to the solution and followed by the addition of mixture containing sodium hydroxide (1M) and sodium carbonate (0.5M) in drop wise until the pH was 9. The precipitate was treated hydrothermally at 120° C to about 8 hours. The synthesized material was filtered, washed several times with double distilled water and dried at 80°C. The obtained product was named as ZAC-LDH. The calcination of ZAC-LDH was done at 450° C for 2 h. Layered double



hydroxide (ZAC-LDH) and its calcined sample (CZA-LDH) were finely grinded and used for further characterization and adsorption studies.

2.2 Characterization of ZAC-LDH and CZA-LDH

Layered structure of ZAC-LDH and CZA-LDH were examined by X-ray diffraction (XRD) pattern by using a Shimadzu XRD-6000 diffractometer, with Ni-filtered Cu-K α radiation ($\lambda = 1.54 \text{ \AA}$) at 40 kV and 200 mA. The surface morphology of samples was analyzed by using field emission scanning electron microscope (FESEM).

2.3 Textile Effluent Analysis

The five different textile dye effluents samples (named as E1, E2, E3, E4 and E5) were collected from different dyeing industries located in Sipcot, Perundurai. In order to know the suitability of ZAC-LDH and CZA-LDH for the real time effluent treatment, batch mode experiments were carried out with the dose of 1g/L of synthesized ZAC-LDH and CZA-LDH for the textile effluent. The percentage of colour removal was calculated by measuring the residual effluent concentration by using Bio spectrophotometer (Elico BL198 make) using the following equation.

$$\% \text{ of dye removal} = ((C_i - C_f) / C_i) * 100 \quad (1)$$

where C_i is the initial dye concentration (mg/L), C_f is the final dye concentration (mg/L)

The other water quality parameters were investigated by using ZAC-LDH and CZA-LDH before and after the adsorption process by standard procedure [16].

III RESULTS AND DISCUSSION

3.1 XRD and SEM images of Synthesized ZAC-LDH and CZA-LDH

X-ray Diffraction patterns of the synthesized Zinc Aluminium Layered Double Hydroxide (ZAC-LDH) and its calcined product (CZA-LDH) were shown in Fig. 1(a) and (b). The observed basal reflections at plane (001), (003) and (110) resembles with original LDH material [17] confirms the LDH structure. On thermal treatment at 450°C, the synthesized ZAC-LDH lose its layered structure into mixed metal oxide with disappearance of planes at (003) and (006) and was shown in Fig.1(b). FESEM images of both ZAC-LDH and CZA-LDH were shown in Fig.2 (a) and (b) and give the surface morphology with pores in homogeneous surface.

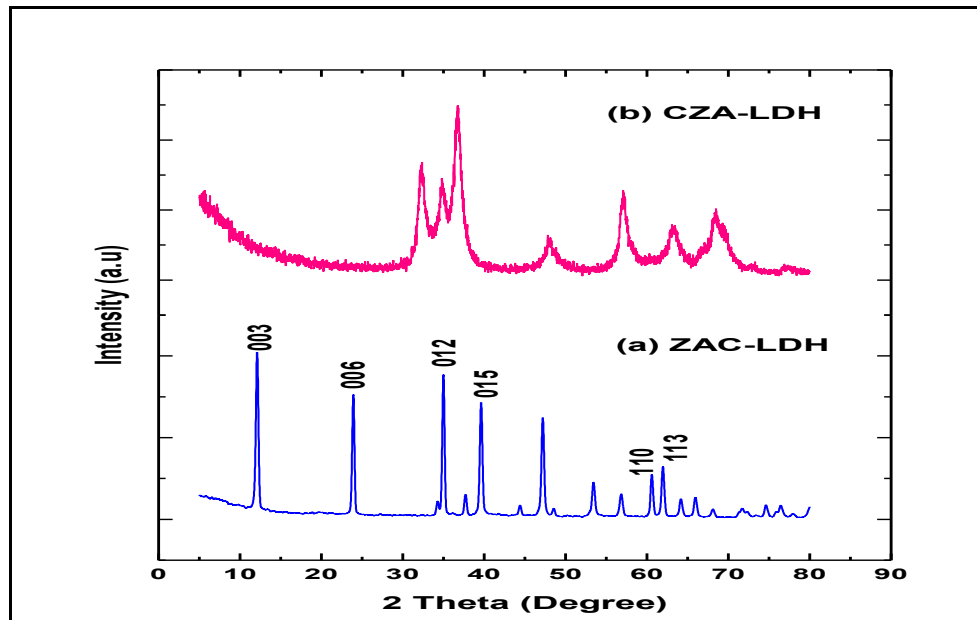
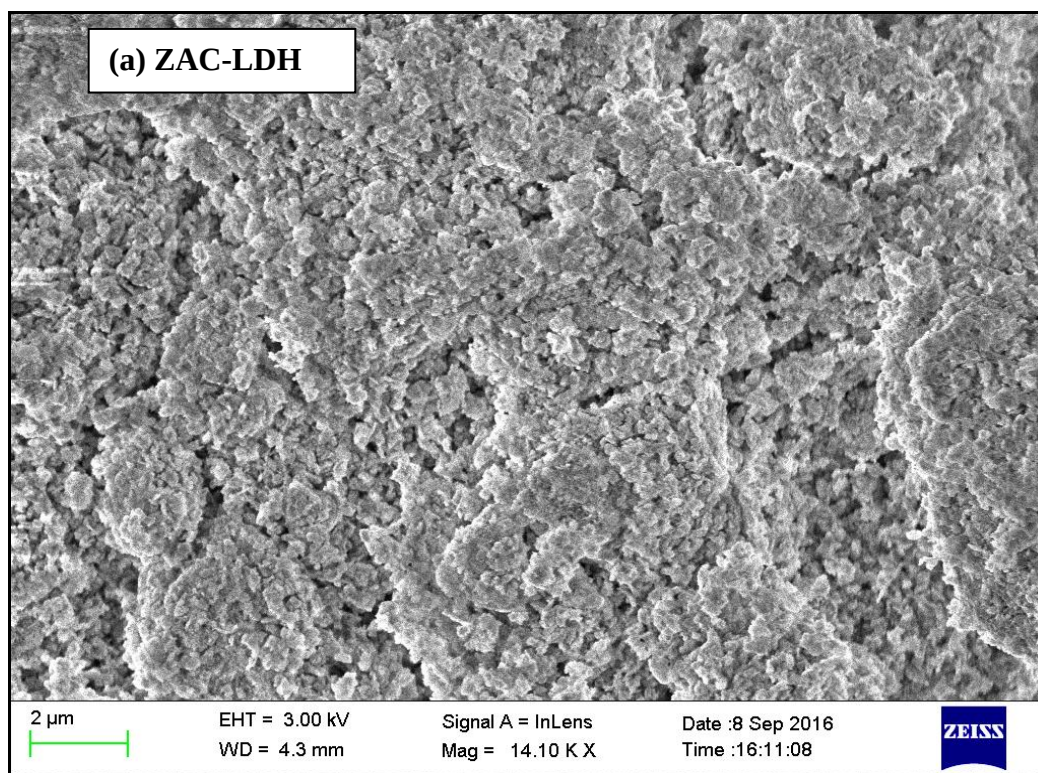


Fig.1 X-Ray Diffraction pattern of (a) ZAC-LDH and (b) CZA-LDH



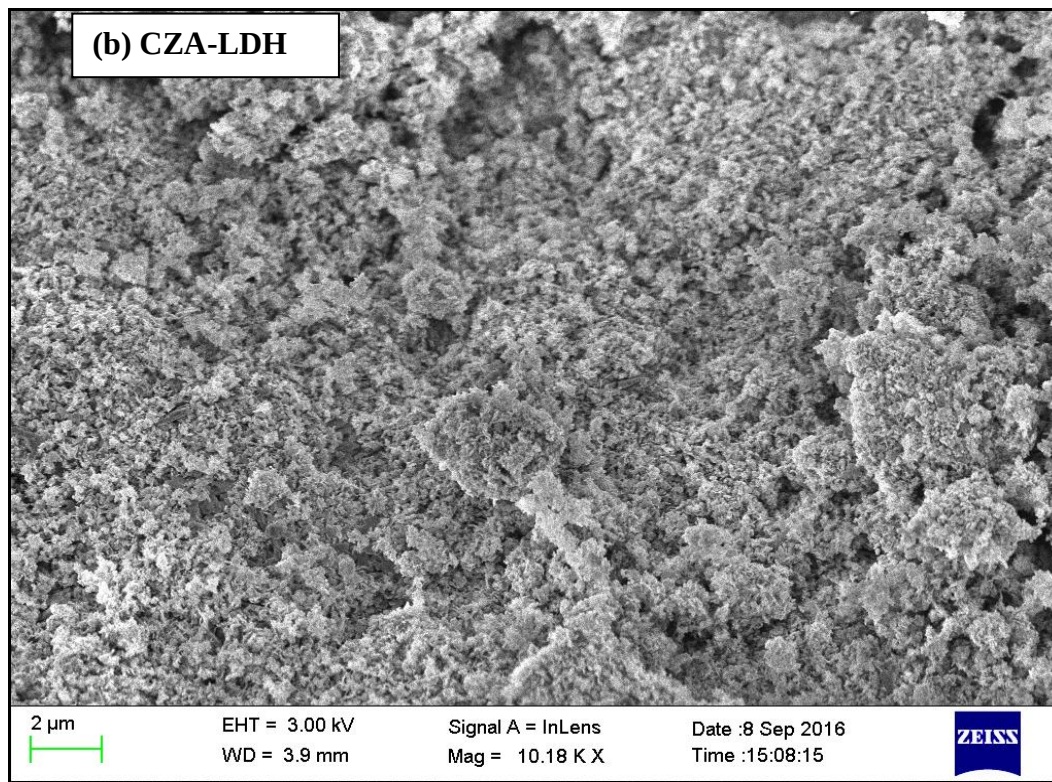


Fig.2 FESEM image of (a) ZAC-LDH and (b) CZA-LDH

3.2 Characterization of Effluent Samples Before and After Adsorption by using ZAC-LDH and CZA-LDH

In order to evaluate the efficiency of synthesized adsorbent materials ZAC-LDH and CZA-LDH, experiments were carried out for some physical and chemical water quality parameters in the real dye house effluent. Before and after the treatment of adsorption processes, Characteristics of Effluent samples (E1 to E5) by both the adsorbent materials were given in Table 1 and 2.

Table 1 Characteristics of effluent samples before and after treatment by using the synthesized adsorbent ZAC-LDH

Parameters	Effluent 1		Effluent 2		Effluent 3		Effluent 4		Effluent 5	
	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
Colour	Violet	Light violet	Dark Green	Colourless	Olive green	Colourless	Orange	Colourless	Yellow	Colourless
% of Colour		63.49	-	80.49	-	80	-	83.33	-	85



Removal										
pH	9.68	7.83	10.78	8.01	9.86	7.39	10.91	7.08	11.77	8.32
Conductivity (µS/cm)	4.24	4.55	8.55	8.49	8.88	8.51	19.64	19.35	15.13	13.79
COD(mg/L)	432	102	820	231	940	256	2420	550	1540	347
TDS(mg/L)	2270	1350	2979	1789	3105	1858	10500	6389	5700	3100
BOD(mg/L)	105	55	289	155	314	145	606	278	422	195
Chloride(mg/L)	967	196.4	1162	275.65	1925	1153.75	3675	1325.24	2485	940.75
Sulphate(mg/L)	30	10	53	22	60	35	289	142	122	48
Alkalinity(mg/L)	655	112	1200	220	800	225	1460	385	1625	510
Hardness(mg/L)	230	63.81	512	26.67	448	31.43	1961	125.71	1384	23.81
Turbidity(NTU)	102	2	138	58	205	15	185	53	175	23

BT- Before Treatment and AT- After Treatment

From the Table 1 and 2, it was observed that the percentage of color removal of all samples by CZA-LDH was more when compared with ZAC-LDH except in 4th sample. The pH measured for all samples were within the permissible level [18].

The values of COD and BOD for all the effluent samples are high before the treatment. But it was observed that an appreciable decrease in COD and BOD value after the treatment with synthesized adsorbents. The maximum percentage of COD removal calculated for all effluents by two materials are in range of 71.83% to 84.46% and was given in Fig.3. More than 90% of reduction in hardness by both the adsorbent ZAC-LDH and CZA-LDH except 1st sample (72.26%) by ZAC-LDH and 3rd sample(75.13%) by CZA-LDH. The observed value of Chloride ion removal in the treated effluent by ZAC-LDH was more when compared with CZA-LDH for all samples. The removal efficiency of alkalinity and sulphate ion by both the ZAC-LDH and CZA-LDH were observed as more or less equal. It is evident from the results; the measured water quality parameters are well within the acceptable limits, which give a way to use the synthesized adsorbent material for the treatment of real dye house effluent.

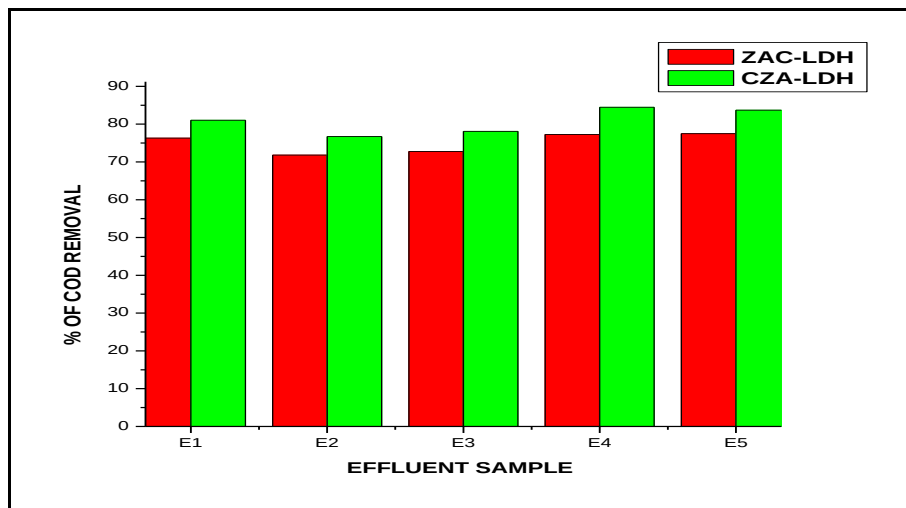


Fig.3. Percentage of COD removal of Effluent sample by ZAC-LDH and CZA-LDH

Table 2 Characteristics of effluent samples before and after treatment by using the Calcined ZAC-LDH (CZA-LDH)

Parameters	Effluent 1		Effluent 2		Effluent 3		Effluent 4		Effluent 5	
	BT	AT	BT	AT	BT	AT	BT	AT	BT	AT
Colour	Violet	Colourless	Dark Green	Colourless	Olive green	Colourless	Orange	Colourless	Yellow	Colourless
% of Colour Removal		73.01	-	95.12	-	85	-	55.56	-	85
pH	9.68	7.06	10.78	7.52	9.86	7.09	10.91	7.56	11.77	8.07
Conductivity (μS/cm)	4.24	4.49	8.55	8.23	8.88	8.37	19.64	19.52	15.13	12.74
COD(mg/L)	432	82	820	191	940	206	2420	376	1540	251
TDS(mg/L)	2270	1125	2979	1522	3105	1635	10500	5894	5700	2667
BOD(mg/L)	105	43	289	125	314	115	606	212	422	127
Chloride(mg/L)	967	435.45	1162	765	1925	1189.85	3675	1473	2485	958.5
Sulphate(mg/L)	30	9	53	22	60	34	289	138	122	41
Alkalinity(mg/L)	655	141	1200	175	800	165	1460	385	1625	485
Hardness(mg/L)	230	20.95	512	17.14	448	111.43	1961	171.43	1384	71.43
Turbidity(NTU)	102	0	138	5	205	13	185	89	175	46

BT- Before Treatment and AT- After Treatment

IV CONCLUSION



In the present study, the ZAC-LDH material was successfully synthesized by co-precipitation followed by hydrothermal process using CTAB as a soft template. ZAC-LDH and its Calcined sample (CZA-LDH) were characterized by XRD pattern and FESEM. The investigation was made with these materials for water quality parameters in real dye house effluent and reveals better performance. The percentage of chemical oxygen demand (COD) removal by ZAC-LDH was observed as 71.83% for 2nd effluent sample and 77.46% for 5th effluent sample. Similarly for CZA-LDH, the COD removal was observed as 76.71% for 2nd effluent sample and 84.46% for 4th effluent sample. Since all water quality parameters results observed were in acceptable limit after the treatment, it substantiates that both the materials used as effective materials for wastewater treatment.

V ACKNOWLEDGEMENT

The Authors gratefully acknowledge the financial support provided by the University Grants Commission (UGC), New Delhi under the Minor Research Project scheme (Project Proposal Number: 1161) to carry out this research work.

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