ISSN: 2278-0181
Vol. 2 Issue 7, July - 2013

Treatment Of Textile Industry Effluent Using Multilayer Thin Films

M. Geetha Devi[1*], Khadija Ali Said Al Omairi[2], S. Feroz[3], Syed Murtuza Ali[4]

[1,2,3,4] *Department of Mechanical and Industrial Engineering,*

Caledonian College of Engineering, Sultanate of Oman

IJERT

Abstract

In this work, investigation of possible use of multilayer nano thin films in the treatment of textile industry effluent and to optimize the processing conditions required to remove the pollutants has been reported. Multilayer thin films were fabricated by alternate adsorption of Chitosan and titanium dioxide on glass substrate. Various experiments have been carried out to study the effect of the treatment conditions such as pH, contact time, number of bilayers and initial dye concentration. The results indicated that optimum conditions obtained are at a pH of 2, a contact time of 90 minutes with an initial dye concentration of 60 ppm for 6 bilayers. The experimental investigation showed that layer-by-layer nano films could effectively reduce contaminants such as Chemical Oxygen Demand (COD), Total Suspended Solids (TSS), Total Solids (TS) and Turbidity.

Keywords: Adsorption, chemical oxygen demand, layer-by-layer, polyelectrolytes, textile mill effluent, thin films.

1. Introduction

Rapid industrialization throughout the developing countries has created generation of toxic pollutants discharged in to the aqueous streams, that are harmful to the human and environment. The major concern is the presence of different types of contaminants that are not adequately removed by conventional water treatment technologies.

The existing ecosystem need protection and new water resources must be developed in order to meet the world's growing demand for clean water. This will require efficient and economic water treatment technology. Photo catalysis using semiconductor materials like TiO_2, ZnO, Fe_2O_3, CdS, and ZnS finds wider application in waste water treatment as advanced oxidation technology. Among these catalysts, TiO_2 is superior due to its availability, stability, low cost, and favorable band gap energy. Although the use of suspended TiO_2 powder is efficient because of the large surface area of catalyst available for reaction, but the main drawback is that the catalyst cannot be recovered and reused efficiently and the process is economically not viable.

One of the largest pollution causing industry in the world is the textile industry. Textile industries consume large quantities of water and discharges highly polluted effluent water to the environment. A typical textile industry effluent is characterized by high value of suspended solids, dissolved organic matters, chemical oxygen demand, biological oxygen demand, colour and turbidity. The discharge of untreated polluted water can cause depletion of dissolved oxygen in the water sources and could pose a risk to public health. High alkalinity and trace amounts of chromium can adversely affects the aquatic environment. Due to environmental constraints, it is necessary to adopt a sustainable approach to recover valuable resources such as water and chemicals. Conventional treatment methods are not very effective in the removal of pollutants such as colour, dissolved solids, suspended solids etc.

Advanced treatment methods are effective due to the pollution removal efficiency and also to provide a scope for recovery of valuable chemicals.The conventional treatment methods include biological treatment, chemical oxidation, coagulation and flocculation methods, membrane technologies, adsorption etc [1- 7]. Biological methods are cheap and simple with high COD removal efficiency but the disadvantages of this process is complete removal of colour is not possible.

Various experiments have been conducted on treatment of textile wastewater to minimize total suspended solids (TSS), chemical oxygen demand (COD), total dissolved solids (TDS) and turbidity [8-19]. Coagulation and flocculation methods are effective on dye removal, but the main drawbacks of these methods are high cost, and generation of large amounts of mud [20-26]. The main objectives of the waste water treatment methods include reuse of treated water, save environment and to protect the public from health risks.

In order to minimize environmental pollution and to protect our environment we have explored the possibility of using multilayer nano thin films in the treatment of textile industry effluent using Chitosan and TiO_2 by layer- by- layer method.

Chitosan is a natural biodegradable polymer made from shrimp or crab shell after deacetylation and purification. Chitosan is inexpensive, nontoxic and stable. Our earlier studies very well shows the application of chitosan in the treatment of waste water from vegetable oil mill [27], dairy [28] industry effluent and heavy metal [29] industries.

The advantages of multilayer thin films by layer- by-layer method are control of film thickness by nanometre precision, possibility to use a wide variety of substrates differing in size, shape and geometry.

IJERT

The research was carried out in Muscat, Sultanate of Oman and the effluent was collected from a leading textile mill in Oman.

2. Experimental section

High molecular weight Chitosan (MW = 650 kDa), and TiO_2 (21 nm Degussa AG, Germany) are purchased from Sigma Aldrich, India. 0.1 N NaOH and 0.1 N HCl are used for pH adjustment. Millipore water (18.2MΩ resistivity) was used in all experiments. To ensure the accuracy, reliability and reproducibility of the collected data, all the batch experiments were carried out in triplicate and the mean values of three data sets were presented.

Investigations were carried out with the effluent before and after treatment. The waste water sample was collected from the outlet of an equalization tank in a textile industry in the sultanate of Oman. The effluent samples are allowed to settle before characterization. The samples are preserved at 4^0C in order to avoid bacterial action. The main parameters studied are COD, TS, TSS, and Turbidity. COD measurements were performed by calorimetric method using spectrophotometer (AQ 400, thermo Scientific Orion and Thermo Reactor Orion COD 125). Turbidity was measured by Turbidity meter (WTW Turb 550).

IJERT

The percentage removal efficiency was calculated by

$$\% \text{ removal efficiency} = \frac{C_0 - C_1}{C_0} \times 100 \qquad (1)$$

Where, C_0 and C_1 are the initial and final concentrations in mg/l respectively.

The effluent concentrations of COD, TSS, TS, and Turbidity are analysed according to standard methods [30].

2.2. *Fabrication of multilayer thin films*

Multilayer thin films are fabricated on glass slide by layer- by - layer method [31]. The fabrication of thin films using Layer –by- Layer (L-b-L) method is used to deposit various materials on different types and shapes of substrates using adsorption technique. The catalyst used for the treatment was TiO_2.

Polyelectrolyte multilayers were fabricated by dipping the clean glass slides into polymer solution of opposite charge (Chitosan) for 20 minutes. After adsorption the excess polymer is removed by washing with water. Then next layer is coated with TiO_2. This procedure is repeated till the desired number of layers is obtained. In all the dipping processes the adsorption time is kept constant. The coated slides are dried and kept ready for the effluent treatment. The whole sequence of the film deposition procedure was repeated till 8 bilayers are obtained. Each bilayers deposition was completed within 50 minutes.

2.3. *Effect of pH*

Effluent samples are prepared at different pH values ranging from 2 to 9 in order to determine the optimum removal efficiency. Coated slides are immersed into a beaker containing 500 ml of effluent sample and exposed to sunlight for a specified time and the samples are filtered and used for analysis.

2.4. *Effect of Contact time*

The effect of variation of contact time on reduction of parameters was studied by varying the contact time between 20 minutes to 140 minutes keeping all other parameters constant.

2.5. *Effect of number of bilayers*

The effect of variation of parameters with number of layers was studied by varying the number of assembling layers from 1 bilayer to 8 bilayers.

2.4. *Effect of Initial Dye concentration*

The initial concentration of effluent was varied from 10 ppm to 90 ppm, while keeping other parameters constant (pH 2, contact time 90 minutes)

3. Results and discussion

3.1. *Effect of pH*

Effect of initial effluent pH was studied by varying the solution pH from 2 to 9. The coated slides are dipped into the effluent solution and exposed to sun light for 90 minutes.

The maximum reduction in COD was noted at a pH of 2 and the maximum TSS removal efficiency was achieved at the same pH. The optimum reduction occurred at pH 2 are due to the higher surface charge density of the surface and at this pH maximum ion transfer will take place, which will facilitate increase in efficiency. As the pH is above 2, the number of available sites decreased thus results in less adsorption and hence decreases in efficiency. The effect of percent reduction in parameters with different pH values are presented in Figure 1.

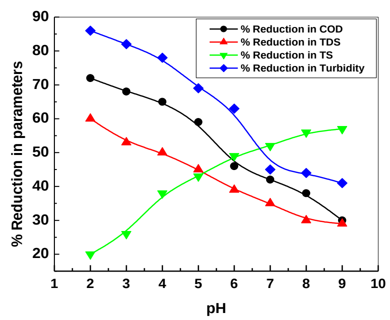

Fig 1. Effect of pH

3.2. *Effect of Contact time*

The effect of variation of contact time on reduction of parameters was studied by varying the contact time between 20 minutes to 140 minutes at an optimum pH of 2. The percentage reduction in COD and TDS occurred at 90 minutes after that it shows a decreasing trend. The percentage reduction in TDS increased with increase in time, up to 90 minutes after which there is a decreasing trend. The percentage reduction in turbidity decreased with increase in contact time. Figure 2 shows the effect of variation of exposure time with parameter reductions.

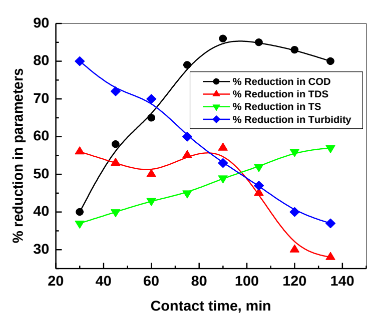

Fig 2. Effect of contact time

3.3. *Effect of number of bilayers*

In order to study the effect of variation of number of layers on reduction of parameters, the number of assembling layers is varied from 1 to 8. The experimental results are indicated in Figure 3. The percentage reduction in COD increased with increase in number of layers up to 6 bilayers after which there is no significant reduction in COD. Reduction in turbidity and TSS also increased with increase in number of bilayers whereas the percentage reduction in TDS decreased with increase in number of bilayers.

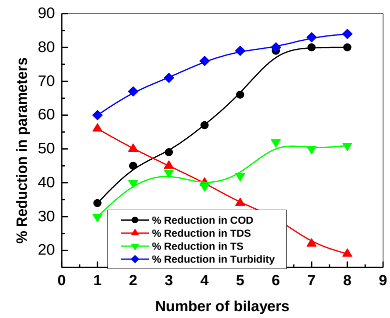

Fig **3**. Effect of number of bilayers

IJERT

3.3. *Effect of initial concentration*

The effect of variation of initial effluent concentration with parameter reduction was studied and the results are represented in Figure 4. It is seen that the percentage reduction in parameters increased with increase in initial dye concentration up to 60 ppm and above which there was no significant change in percentage reduction in parameters.

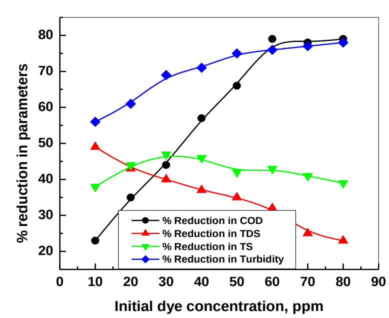

Fig 4. Effect of initial dye concentration

4. Conclusion

Based on the above study it is seen that multilayer thin films fabricated by the L-b-L method finds good scope for the treatment of textile industry effluent in an efficient and environmental friendly manner. In this study titanium dioxide acts as a catalyst, which finds wider application due to its easy availability, stability, low cost, large surface area and a good band energy gap. There has been an increasing interest in the fabrication of thin films using Chitosan. Multilayer nano thin films are reported to be one of the most promising technologies for the treatment of textile effluents by saving considerable amount of money.

Acknowledgements

The authors express their sincere thanks to Industry Innovation Centre (IIC), for providing the research grant.

5. References

[1] A. Bes-Pia, J.A. Mendoza-Roca, M.I. Alcaina-Miranda, A. Iborra-Clar and M.I. Iborra-Clar, "Reuse of wastewater of the textile industry after its treatment with a combination of physico-chemical treatment and membrane technologies", *Desalination*, 2002, 149:169–174.

[2] C.D. Adams, W. Fusco, and T. Kanzelmeyer, "Ozone, hydrogen peroxide/ozone and UV/ozone treatment of chromium and copper complex dyes: decolorization and metal release", *Ozone Sci. Eng*, 1995, 17:149-161.

[3] A. Al-Kdasi, A. Idris, K. Saed and C. Teong Gua, "Treatment of textile wastewater by advanced oxidation processes", *Global Nest: the Int. J*, 2004,Vol 6, No 3, pp 222-230.

[4] A. Akbari, J. C. Remigy, and P. Aptel,"Treatment of textile dye effluent using a polyamide-based nanofiltration membrane", *Chem. Eng. Proc*, 2002, 41:601-609.

[5] I. Arslan, I.A. Balcioglu, and D.W. Bahnemann, "Advanced chemical oxidation of reactive dyes in simulated dyehouse effluents by ferrioxalate-Fenton/UV-A and TiO2/UV-A processes", *Dyes Pigments*, 2000, 47:207-218.

[6] B. Ramesh Babu, A.K. Parande, S. Raghu and T. Prem Kumar "Cotton textile processing: waste generation and effluent treatment", *The Journal of Cotton Science*, 2007, 11:141–153.

[7] C. Peyratout, E. Donath, L. Daehne "Electrostatic interactions of cationic dyes with negatively charged polyelectrolytes in aqueous solution", *Max-Planck-Institute of Colloids and Interfaces*, 2001, D-14474 Golm/Potsdam, Germany, Volume 142, P 51–57.

[8] G. Ciardelli, and N. Ranieri," The treatment and reuse of wastewater in the textile industry by means of ozonation and electroflocculation" *Water Res*, 2001, 35: 567-572.

[9] E. K. Mahmoud "Chemically enhanced primary treatment of textile industrial effluents", *Polish J. of Environ. Stud*, 2009, Vol. 18, No. 4, 651-655.

[10] A. Erswell, C.J. Brouchaert, and C.A. Buckley, "The reuse of reactive dye liquors using charged ultra filtration membrane technology", *Desalination*, 1988, 70:157-167.

[11] F. H. Hussein And T.A. Abassa," Photocatalytic treatment of textile industrial wastewater", *Int. J. Chem. Sci*, 2010, 8(3), P1353-1364.

[12] F. N. Crespilho, V. Zucolotto, O. N. Oliveira Jr and F. C. Nart,"Electrochemistry of Layer-by-Layer films", *Int. J. Electrochem. Sci*, 2006, 1, 194-214.

[13] F.Gaehr, F. Hermanutz, and W. Oppermann, "Ozonation an important technique to comply with new German laws for textile wastewater treatment", *Water Sci. Technol*, 1994, 30: 255-263.

[14] S.B. Ghayeni, P.J. Beatson, R.P. Schneider, and Fane, A.G, "Water reclamation from municipal wastewater using combined microfiltration-reverse osmosis (MERO): Preliminary performance data and microbiological aspects of system operation", *Desalination*, 1998, 116:65-80.

[15] J. Radjenovi, M. Matosi, I. Mijatovi, M. Petrovi and D. Barcelo, "Membrane Bioreactor (MBR) as an Advanced Wastewater Treatment Technology", *Hdb Env Chem*, 2008, 5: 37–101.

[16] S. Ledakowicz, M. Solecka, and R.Zylla, "Biodegradation, decolourisation and detoxification of textile wastewater enhanced by advanced oxidation processes", *J. Biotechnol*, 2001, 89:175-184.

[17] R. Maier, W. Schrott, T. Bechtold, and C.R. Melliand, "Electrochemical bleaching in the finishing of jeans" *Tdberichte* , 2004, 85:11-12.

[18] M. A. Kamaruddin, M. S. Yusoff, H. A. Aziz and C. O. Akinbile,"Recent developments of textile waste water treatment by adsorption process, *International Journal of Scientific Research in Knowledge (IJSRK)"*, 2013, 1(4), pp. 60-73.

[19] N. Tufekci, N. Sivri and I. Toroz ,"Pollutants of Textile Industry Wastewater and Assessment of its Discharge Limits by Water Quality Standards", *Turkish Journal of Fisheries and Aquatic Sciences*, 2007, 7: 97-103.

[20] O. O. Ogunlaja and O. Aemere," Evaluating the efficiency of a textile wastewater treatment plant located in Oshodi, Lagos", *African Journal of Pure and Applied Chemistry*, 2009, 11: 189-196.

[21] A. Pala, and E. Tokat, "Color removal from cotton textile industry wastewater in an activated sludge system with various additives", *Water Res*, 2002, 36:2920-2925.

IJERT

[22] U. Rott, and R. Minke, "Overview of wastewater treatment and recycling in the textile processing industry", *Water Sci. Technol,* 1999, 40:37-144.

[23] R.O. Yusuff and J.A. Sonibare, "Characterization of textile industries' effluents in Kaduna, Nigeria and pollution implications", *Global Nest: the Int. J, 2004,* Vol 6, No 3, pp 212-221.

[24] V. Conceicao, F. B. Freire and K. Querne de Carvalho ," Treatment of textile effluent containing indigo blue dye by a UASB reactor coupled with pottery clay adsorption", Maringa, 2013, Vol. 35, No. 1, p. 53-58.

[25] Vinod G. Jogdand, Prajakta. A. Chavan, Pramod D. Ghogare and Ajaykumar G. Jadhav Remediation of textile industry waste water using immobilized Aspergillus terreus, Institute of Science, 2012 Aurangabad, MS, India.

[26] Y. Damar, A. Ates and R. Ileri,"Treatment of textile industry wastewater by sequencing batch reactor (SBR), modelling and simulation of biokinetic parameters", *International Journal of Applied Science and Technology,* 2012, Vol. 2 No. 3.

[27] M. Geetha Devi, Z. S. Shinoon Al-Hashmi, G. Chandra Sekhar,'Treatment of vegetable oil mill effluent using crab shell chitosan as adsorbent", *Int. J. Environ. Sci. Technol*, 2012, 9:713–718.

[28] M. Geetha Devi, Joefel Jessica Dumaran , S. Feroz, "Dairy Wastewater Treatment Using Low Molecular Weight Crab Shell Chitosan", *J. Inst. Eng. India Ser. E,* 2012, 93(1):9–14.

[29] M. Geetha Devi , G. Chandrasekhar," A batch Study on Adsorption of Zinc (II) Using High Molecular Weight Crab Shell Chitosan and Date Seed Carbon*", International Journal of Biotechnology, Chemical & Environmental Engineering* , 2012, Vol.1, (3), 22-26.

[30] American Public Health Association (APHA-AWWAWPCH). 1998. Standard Methods for the Examination of Water and Waste Water. 20th ed. APHA Washington D.C., 1270 pp.

[31] G. Decher, "Fuzzy Nanoassemblies: Toward Layered Polymeric Multicomposites", *Science*, 1997, 277, 5330, 1232-1237.

IJERT