Potential of Cellulose Acetate for the Removal of Methylene Blue Dye from Aqueous Streams

Jyoti Rana, Gyanendra Goindi, Navneet Kaur

Abstract*: *In present study adsorption behavior of Cellulose Acetate for removal of Methylene blue has been studied in a batch wise mode. Adsorption experiments were conducted using 100 ml of dye solution (10ppm), pH (2-9) and adsorbent dose (0.5-2.0 g) at 150 rpm at 25oC. Rate of decolonization was estimated from residual concentration spectrophotometrically. The experimental results indicated that cellulose Acetate can effectively remove 60% dye from aqueous streams. The high decolorizing efficiency was obtained with 1.0 g/l of adsorbent dose. Cellulose Acetate was characterized by using FTIR Fourier transform infrared spectroscopy analysis and SEM Scanning electron microscopy analysis..

Index Terms*: *Cellulose Acetate, Methylene Blue, Adsorption, Adsorption isotherms..

I. INTRODUCTION

Due to scarcity of water resources, reuse of water has become necessity. The load on environment and human can be reduced by treating this waste water in effective way and reusing it again and again. One of major reasons of water contamination is rapid industrialization; the effluent streams are either not treated or partially treated and discharged into the water bodies. Textile industries are one of the major contributors to this. In the dyeing process after dying the textile material, the residue (2-50%) goes as a waste in aqueous solutions [1], or rarely treated [2]. There are numerous types of dyes used in textile industry, Basic dyes are one class among them which are measured as more problematical type of dye. These Basic dyes have been classified as toxic colorant [3]. Methylene Blue (MB) is basic dye used in textile industries. Accidental large dose of MB causes adverse effect on human body such as stomach and chest pain, migraine , plentiful sweating, confusion, painful micturation and methemoglobinemia [4]. Therefore it is essential to eliminate dyes like methylene blue from textile effluent by adoption some cost effective technology. There are different technologies to treat waste water, such as coagulation, flocculation [5], photo catalytic degradation, membrane filtration, microbiological decomposition, electrochemical oxidation [6][7][8] adsorption using fungi biosorbent [9] have been used. Among these methods, adsorption is marked as an effective method, because of its low cost factor, high efficiency and simple process [10] Adsorption has more advantages than the other conventional methods [11].The major factors due to which adsorption has gained importance are low initial cost, easy operation, simple design and negligible or a lesser amount of production of toxic substances [12] .

Revised Manuscript Received on August 01, 2019
Er. Jyoti Rana, Assistant Professor, Chandighar University
Dr. Gyanendra Goindi, Professor, Chandigahr University
Dr. Navnnet Kaur, Associate Professor, Chandighar University

Activated carbon has been reported as an perfect adsorbent to reduce the dye concentration from waste water streams [13][14]. Though, the use of activated charcoal is restricted because of its higher cost factor and high attrition rate [15][16]. So the search for alternative adsorbent is excelling ,researchers have explored many alternative adsorbent, one of adsorbent which have been emerging as potential alternative to activated carbon is biopolymers. These biopolymers have vast surface area, impeccable mechanical rigidity changeable surface chemistry, porosity, regenerability under mild conditions. Various biopolymers which can be used are Chitosan, Chitin, Cellulose acetate etc [17][18], Cellulose acetate is one of the widely used biopolymer [19]. Cellulose acetate, a derivative of cellulose, can also be used as an adsorbent. Cellulose acetate is a biodegradable polymer. We are reporting the use of cellulose acetate as an adsorbent for the elimination of Methylene blue from waste water streams.

II. EXPERIMENTAL INVESTIGATIONS

A. MATERIALS

Cellulose Acetate and Methylene Blue from (Merck) were used in present study without further purification. Millipore water was used for the preparations of the various solutions.

B. CHARACTERIZATION OF CELLULOSE ACETATE

An FTIR spectrum of pure Cellulose Acetate was recorded on Perkin Elmer-RXI FT-IR. For the investigation of functional groups which are present in CA, the analysis was done 1 at 4 cm-1 resolution between between 500 to 4000 cm-. Scanning Electron Microscopy (SEM) image was taken with Model JSM6100 (Jeol) with sputter coating of material.

C. BATCHWISE PROCESS FOR THE ADSORPTION OF METHYLENE BLUE USING CELLULOSE ACETATE

For investigating the potential of CA for the elimination of MB from aqueous stream, batch adsorption experiments were carried. For each batch study, the required amount of CA was put to 100 mL of 10ppm methyle blue solution in a conical flask and further kept on mechanical shaker for 120 min for agitated. After certain contact time the conical flasks were removed from mechanical shaker, Filtration was done using syringe filters to remove adsorbent (CA) the and further concentration of the supernatant solution was examined spectrophotometrically. All the tests were replicated three times and results were averaged. Similar investigations were carried out by varying adsorbent dose (0.5- 2.0g), concentration of dye solution (5-50ppm) and contact time (30-240 min).

The percentage removal of MB (R%) at equilibrium (Qe) was calculated for each investigation using Eq. 5:

$$R\% = (C_i - C_e)/C_i \times 100 \quad (5)$$

Where initial concentration of Methylene blue is symbolized as Ci and final concentration of Methylene blue as Ce

The uptake capacity of CA was from the mass balance as shown below

$$Qe(mg/g) = (Ci - Ce)/M \times V \quad (6)$$

Where Qe is the quantity of sorbate (MB dye) uptaken by CA

V = volume in (L)

M = Mass of adsorbent (g).

III. RESULTS AND DISCUSSIONS

A. FT-IR SPECTRUM

The spectrum shows first small peak at 3500cm-1 (vOH) due to hydrogen bonding, Other appearance of an absorption band were found at 1628 cm-1 and 1736 cm-1 indicating C=O group of CA. The band obtained at 1218 cm-1 and 1033 cm-1 indicates of C-O-C bond. Further C-H stretching of cellulose are also obtained by the band nearly around 1387 cm-1. Kanagaraj et al., 2016 also reported same observations . Figure 1. Shows the FTIR of CA.

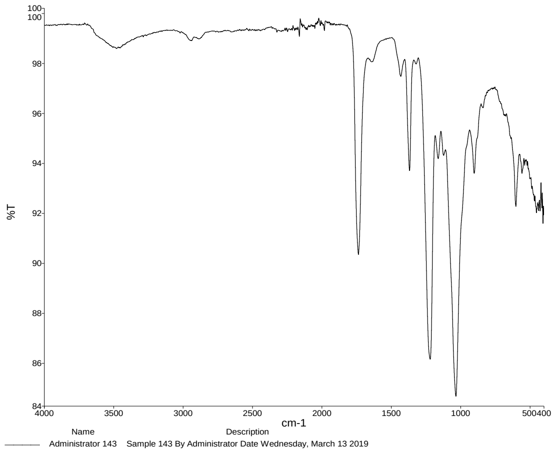

Figure.1 FTIR images of CA

B. SCANNING ELECTRON MICROSCOPY (SEM)

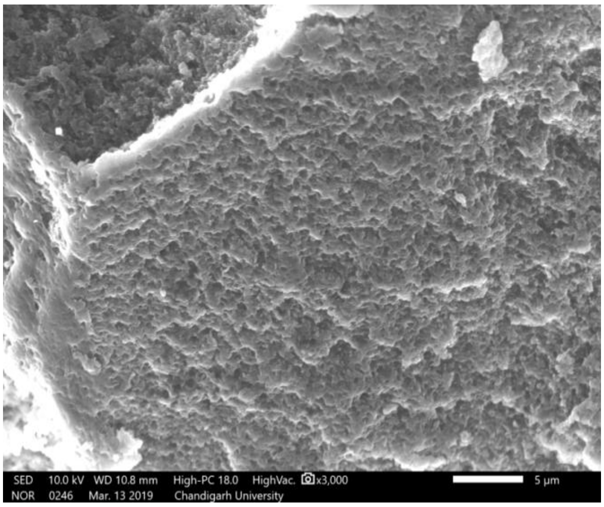

Figure.2. Scanning electron microscopy images of Cellulose Acetate

The SEM images shows dense pores in the surface of CA. Indicating modifications required for increasing the effectiveness of CA as an adsorbent.

C. ADSORPTION OF METHYLENE BLUE

1. **Adsorption process with varying contact time**

With rise in contact time the rate at which the MB is adsorbed by CA also increases. The maximum removal was at a contact time of 260 minutes. Later it almost becomes constant with increase in contact time.260 min was taken as optimum time in adsorption experiments**.**

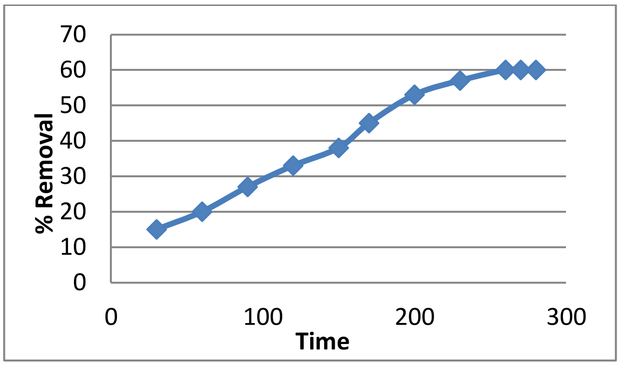

Figure.3 . Adsorption process with varying contact time

2. **Adsorption process with varying adsorbent dosage**

MB solution of 10ppm concentration was used in combination with virgin CA sample of 0.5,1,1.5,2,2.5,3 gm/100ml .Contact times and pH were 260 min and 7.6.. The optimum dose was 1g/100ml.At which 60 % of removal efficiency is achieved. With further increment in dose there is slight increment in the % removal so optimum dose selected is 1gm/50ml.

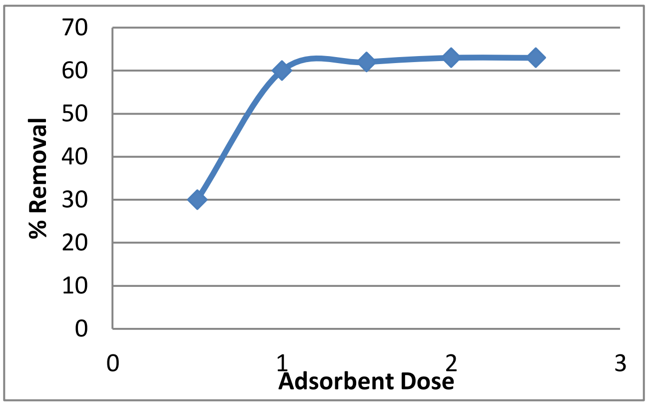

Figure.4 Adsorption process with varying adsorbent dose

3. The effects of pH

The pH of the dye solution has high impact in whole adsorption process and acts as an important factor in the adsorption capacity. The dye –CA relations is shown in fig below. low adsorption rate was observed and at pH 2. At pH 4-7 adsorption increases from 44% to 60 %. At pH 7 the adsorption was 60% and at 7.

6 pH the adsorption was 61 %With further increase in pH the % removal starts decreasing. Therefore the highest adsorption capacity was found at pH 7.6. Above and under this point, adsorption of Methylene Blue decreases

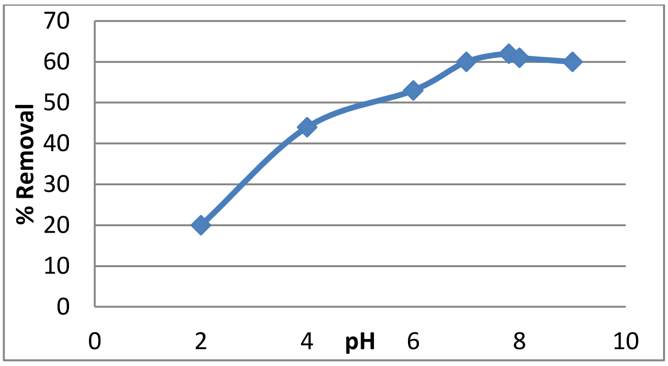

Figure.5 Effect of pH on adsorption

4. The effect of Dye Concentration

From the stock solution, different dye solutions of 5,10,25,50 and 100 ppm were made by serial dilutions.100 ml of 5,10,25,50 and 100 ppm methylene blue solutions were taken in conical flask. Fixed dose of 1gm/100ml of CA was added to each flask and batch adsorption was carried for 260 minute. The % removal for 5,10,25,50,100 ppm was 75,38,25,20 %.Which shows that with increase in concentration of dye the % removal decreases.

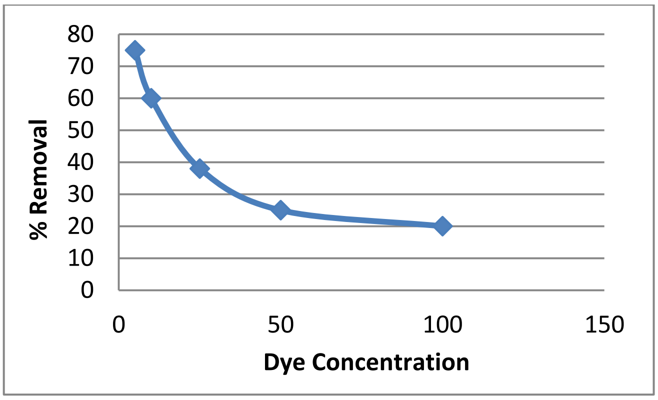

Figure. Adsorption process with varying dye concentration

IV. CONCLUSION

The result of present study clearly shows that that CA can remove Methylene blue dye from aqueous streams but further modification are required to enhance its adsorption properties. The results shows 60 % colour removal efficiency can be achieved at the dose of 1g/100 ml i.e 1gof CA in 100ml of 10ppm dye solution. pH of 7.6 is the optimal pH for studies indicating further modification to increase its effectiveness.

REFERENCES

1. Padhi, B.S., 2012. Pollution due to synthetic dyes toxicity & carcinogenicity studies and remediation. International Journal of Environmental Sciences, 3(3), p.940.
2. Terinte, N., Manda, B.M.K., Taylor, J., Schuster, K.C. and Patel, M.K., 2014. Environmental assessment of coloured fabrics and opportunities for value creation: spin-dyeing versus conventional dyeing of modal fabrics. Journal of cleaner production, 72, pp.127-138.
3. Anliker, R., Duerig, G., Steinle, D. and Moriconi, E.J., 1988. List of colorants to be classified as toxic. Journal of the Society of Dyers and Colourists, 104(5-6), pp.223-225.
4. Ghosh, D., & Bhattacharyya, K. G. (2002). Adsorption of methylene blue on kaolinite. Applied Clay Science, 20(6), 295–300.
5. Lee, J.W., Choi, S.P., Thiruvenkatachari, R., Shim, W.G. and Moon, H., 2006. Evaluation of the performance of adsorption and coagulation processes for the maximum removal of reactive dyes. Dyes and pigments, 69(3), pp.196-203.
6. Malik, P.K. and Saha, S.K., 2003. Oxidation of direct dyes with hydrogen peroxide using ferrous ion as catalyst. Separation and purification technology, 31(3), pp.241-250.
7. Koch, M., Yediler, A., Lienert, D., Insel, G. and Kettrup, A., 2002. Ozonation of hydrolyzed azo dye reactive yellow 84 (CI). Chemosphere, 46(1), pp.109-113.
8. Pearce, C.I., Lloyd, J.R. and Guthrie, J.T., 2003. The removal of colour from textile wastewater using whole bacterial cells: a review. Dyes and pigments, 58(3), pp.179-196.
9. Fu, Y. and Viraraghavan, T., 2002. Removal of Congo Red from an aqueous solution by fungus Aspergillus niger. Advances in Environmental Research, 7(1), pp.239-247.
10. Wong, Y. C., Ranjini, K. N., and Wan-Nurdiyana, W. A., 2014. Removal of Congo Red and Acid Yellow 36 Dye Using Orange Peel and Rice Husk as Absorbent. Oriental Journal of Chemistry, 30(2), 529-539..
11. Gupta, V.K. and Imran, A., 2015. Water treatment: low-cost alternatives to carbon adsorbents. In Encyclopedia of Surface and Colloid Science (pp. 7618-7652). CRC Press.
12. Crini, G. (2006). Non-conventional low-cost adsorbents for dye removal: a review. Bioresource technology, 97(9), 1061-1085.
13. Bhatnagar, A., Hogland, W., Marques, M. and Sillanpää, M., 2013. An overview of the modification methods of activated carbon for its water treatment applications. Chemical Engineering Journal, 219, pp.499-511.
14. Choy KKH, McKay G, Porter JF (1999) Sorption of acid dyes from effluents using activated carbon. Resour Conserv Recycl 27:57–71
15. Hubbe, M.A., Hasan, S.H. and Ducoste, J.J., 2011. Cellulosic substrates for removal of pollutants from aqueous systems: A review. 1. Metals. BioResources, 6(2), pp.2161-2287.
16. Vakili, M., Rafatullah, M., Salamatinia, B., Abdullah, A.Z., Ibrahim, M.H., Tan, K.B., Gholami, Z. and Amouzgar, P., 2014. Application of chitosan and its derivatives as adsorbents for dye removal from water and wastewater: A review. Carbohydrate polymers, 113, pp.115-130.
17. Hokkanen, S., Bhatnagar, A. and Sillanpää, M., 2016. A review on modification methods to cellulose-based adsorbents to improve adsorption capacity. Water research, 91, pp.156-173.
18. Batmaz, R., Mohammed, N., Zaman, M., Minhas, G., Berry, R.M. and Tam, K.C., 2014. Cellulose nanocrystals as promising adsorbents for the removal of cationic dyes. Cellulose, 21(3), pp.1655-1665.
19. Kanagaraj, P., Nagendran, A., Rana, D. and Matsuura, T., 2016. Separation of macromolecular proteins and removal of humic acid by cellulose acetate modified UF membranes. International journal of biological macromolecules, 89, pp.81-88.

AUTHORS PROFILE

Er. Jyoti Rana
Assistant Professor, Chandighar University

B.tech, M..E Chemical Engg, working as assistant Professor in Chandigarh University, Have published many papers in reputed journals.

Dr. Gyanendra Goindi,
Professor, Chandigahr University

PhD(, IIT Ropar)Having 20 years of industrial and academic experience, Currently working ad HOD Mechanical ,Chandigarh University. Have published many papers nation and international in reputed journals ,and attended national and international conferences.

Dr. Navnnet Kaur
Associate Professor, Chandighar University

HOD Chemical Engineering Departmant ,PhD Chemical Engineering, Having 10 years of teaching experience. Have published many nation and international papers in reputed journals.

.