Removal of crystal violet dye from aqueous solution by CuS-CdS material

P. M. Dighe

Department of Physics and Research Center, Padmashri Vikhe Patil College of Arts, Science and Commerce, Pravaranagar (M. S), India

(Affiliated to Savitribai Phule Pune University, Pune)

Abstract: The CuS-CdS materials were used for the removal of crystal violet dye. The removal of crystal violet dye from aqueous solution at different concentration of crystal violet dye, amount of CuS-CdS materials, temperature, contact time and pH has been studied.

Keywords: CuS-CdS materials, crystal violet, adsorption etc.

1. Introduction

Nowdays, water has been contaminated due to industrialization as well as man-made processes. The waste water effluents from industries like printing, food processing, leather, rubber, pulp, textile, plastic and cosmetics contain the different dyes [1]. It's very difficult to treat the effluents because of its chemical structure [2]. The effluents also contain inorganic and organic material, salts, surfactant, additives etc. The human beings and living organism are affected due to such materials and other contaminants [3]. The effluents polluted the ground water and degrades the quality of water and soil, hence it affects the environment [4]. In India most of the industries work on dyestuffs and produced the hazardous effluents in the water so the industry also facing the problem in environmental pollution. The crystal violet dye is a carcinogenic [5], it affects the water bodies which causes growth of tumours in fish and affects the aquatic life [6]. The crystal violet is consisting of many stable functional groups and due its aromatic nature it's difficult to decompose [7]. Crystal violet is a positive charged and the cationic triphenylmethane type dye [8]. Crystal violet is used in the industries like veterinary fields, printing, dyeing and dermatology [9].

The large number materials are used for the removal of crystal violet and other dyes from water like, palm kernel shell-derived biochar [10], sugarcane [11], mango leaves [12], pine sawdust [13], mushrooms [14], peanut shells [15], cabbage waste [16], woody trees [17], dew melon peel [18], water hyacinth [19], jackfruit leaf powder [20], grapefruit peel [21], ginger waste [22], rice husk [23], activated carbon derived from active sludge [24] and murraya koenigii stem biochar [25].

In the present protocol the removal of crystal violet dye has been studied by using the CuS-CdS materials. The important parameters such as concentration of crystal violet dye, amount of chicken eggshells waste, pH and nature of chicken eggshells waste were investigated.

2. Materials and Methods

The crystal violet dye was purchased from Merck Ltd. (India) and by dissolving 0.3 gm of dye in 1000 ml of distilled water 300 ppm of dye solution was obtained. The solution of different concentrations of dye was prepare by using above stock solution. The absorbance of the crystal violet dye solution was measured using UV spectrophotometer at wavelength 580 nm. The initial pH of dye solution was adjusted by using dilute hydrochloric acid or sodium hydroxide solution. The CuS-CdS material was synthesized by the known method [26]

3. Results and discussions

3.1. Effect of pH:

The surface properties of adsorbent material and dissociation of dye molecules are extremely affected by the pH of the solution. The adsorption capacity was studied over a pH range of 2-12. The removal of crystal violet dye was increases with increase in pH value up to 8. Beyond the pH value 8 the adsorption of dye was decreases. The results obtained are shown in figure 1. At low pH there is high concentration of H+ ions which results in repulsion and

therefore less amount of biosorption. At higher pH more negatively charged surfaces are available which reduced the adsorption.

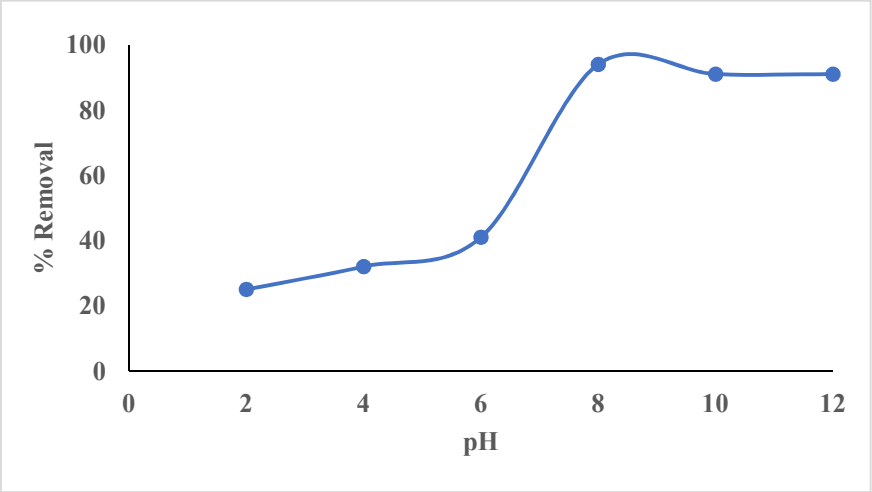

Figure 1

3.2. Effect of concentration of dye:

To study the effect of concentration of the dye on the adsorption of the surface of CuS-CdS material. The concentration of the dye varied from 50 ppm to 300 ppm. The removal of the crystal violet dye was carried out at pH 8.0 and different concentration of the dye solution. The maximum dye removal was observed at 50 ppm of the dye solution. The results were depicted in figure 2.

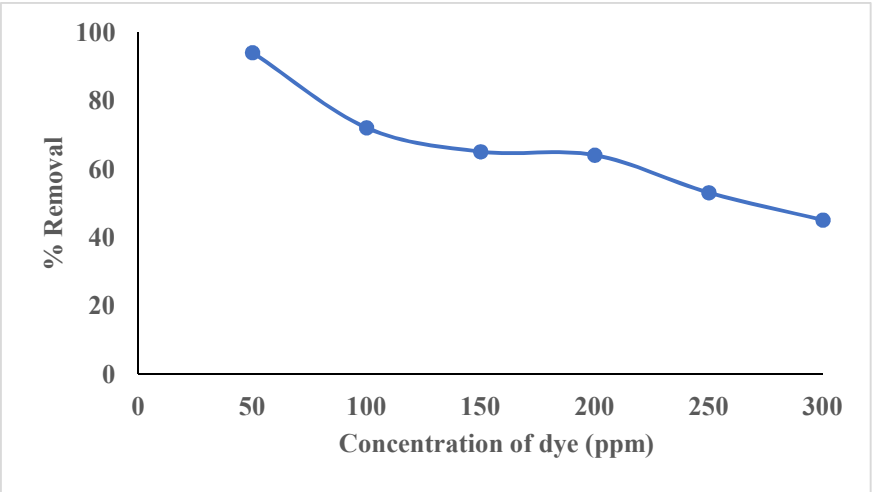

Figure 2

3.3. Effect of amount of CuS-CdS:

The 50 ml dye solution of 50 ppm was used to study the amount CuS-CdS material. The removal of the crystal violet was carried out at pH 8.0. The increase in CuS-CdS from 0.5 to 4.0 gm, the percentage removal was found to increase rom 73 % to 91 %. Due to saturation of binding sites due to aggregation of adsorbed materials. The removal of the crystal violet dye was observed maximum at 1.5 gm of the CuS-CdS material.

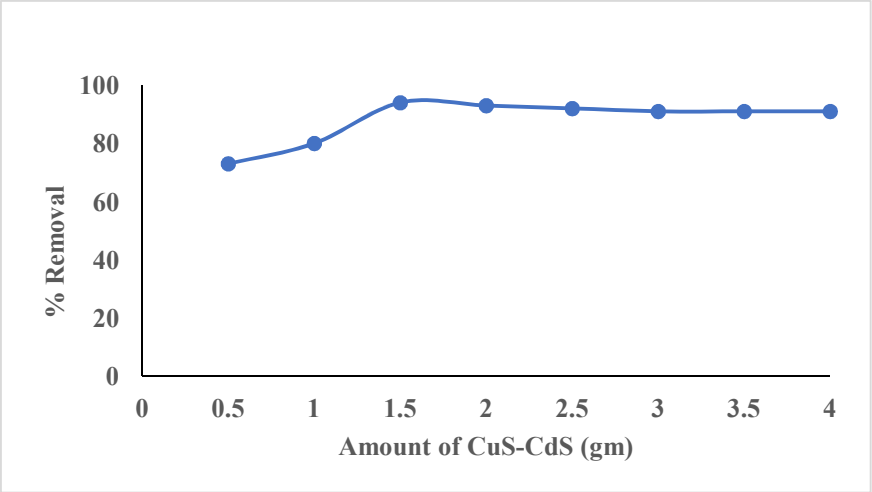

Figure 3

3.4. Effect of contact time:

The contact time was varied from 10 min to 100 min to study the removal of crystal violet from aqueous solution. The 50 ml dye solution was used for the experiment. The experiment was carried out at pH 8.0 with 1.5 gm of CuS-CdS adsorbent material and 50 ppm initial concentration of the dye solution. It is observed that the removal of crystal violet dye is rapid within 30 min of contact time due to high concentration gradient and the availability of large surface area of biosorption.

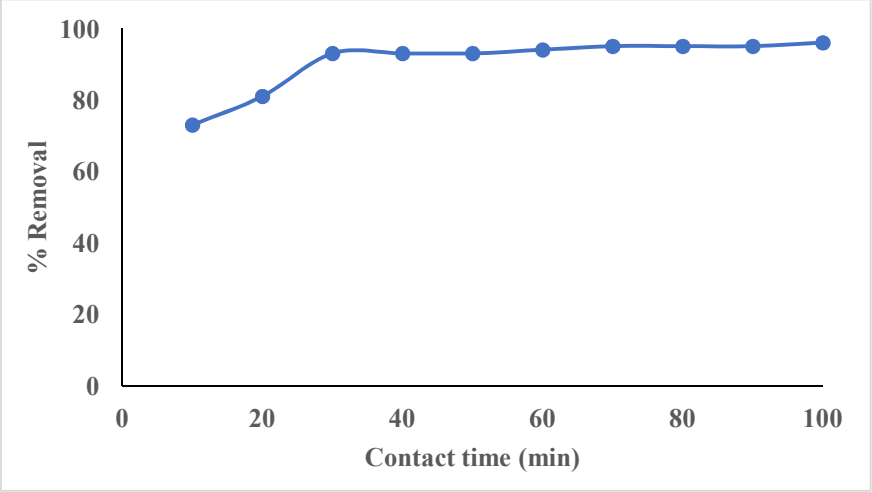

Figure 4

3.5. Effect of temperature:

To study the effect of temperature on the removal of crystal violet, the temperature was varied from 300 K to 315 K. A maximum removal of the dye was obtained at 303 K. The adsorption of the crystal dye decreases with increase in temperature. The result suggests that the adsorption phenomenon is kinetically controlled by an exothermic process.

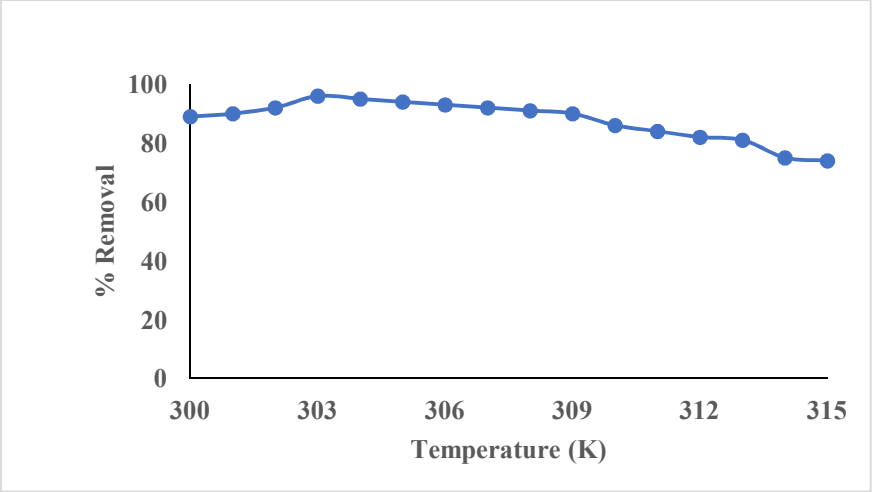

Figure 5

4. Conclusion

The present paper demonstrates that CuS-CdS material can be used as adsorbent for the removal of crystal violet from aqueous solution. The results show that the removal of crystal

violet dye is influenced by factors such as amount of adsorbent, initial concentration of dye, pH, contact time and temperature. The optimum conditions for the removal of dye are pH 8, initial concentration of dye 50 ppm, amount of adsorbent 1.5 gm, contact time of 30 min and at temperature 303 K. The adsorption results showed that the crystal violet dye was strongly adsorbed on to the CuS-CdS material.

5. Acknowledgements

The authors are thankful to the Management of Padmashri Vikhe Patil College of Arts, Science and Commerce, Pravaranagar for providing the necessary facilities.

References

1. Chiou MS, Ho P, Ho Y, Li HY. (2004). Adsorption of anionic dyes in acid solutions using chemically cross-linked chitosan beads, Dye Pigments 60 (1): 69-84. Available from: http://dx.doi.org/10.1016/S1043-7208(03)00140-2
2. Kumar PS, Saravanan A. (2017). A Volume in the Textile Institute Book Series, Woodhead Publishing, Chennai, India, pp. 323-346.
3. M. Iqbal, M. Abbas, J. Nisar, Nazir, Qamar AZ. (2019). Bioassays based on higher plants as excellent dosimeters for ecotoxicity monitoring: A review, Chem. Int. 5 (1): 1-80. Available from: http://dx.doi.org/10.5281/zenodo.1475399
4. Yagub MT, Sen TK, Ang HM. (2012). Equilibrium, kinetics, and thermodynamics of methylene blue adsorption by pine tree leaves. Water Air Soil Pollut. 223: 5267-5282. Available from: http://dx.doi.org/10.1007/s11270-012-1277-3
5. Chakraborty S, Chowdhury S, Saha PD. (2011). Adsorption of crystal violet from aqueous solution onto NaOH-modified rice husk. Carbohydr. Polym. 86 (4): 1533-1541. Available from: http://dx.doi.org/10.1016/j.carbpol.2011.06.058

6. Ali H, Muhammad SK. (2008). Biosorption of crystal violet from water on leaf biomass of calotropis procera. Environ. Sci. Technol., 1 (3): 143-150. Available from: http://dx.doi.org/10.3923/jest.2008.143.150

7. Alsenani G. (2013). Studies on adsorption of crystal violet dye from aqueous solution onto calligonum comosum leaf powder (CCLP). Am. J. Sci. 9 (8): 30-35. Available from: http://www.jofamericanscience.org. 5

8. Wu J, Gao H, Yao S, Chen L, Gao Y, Zhang H. (2015). Degradation of crystal violet by catalytic ozonation using Fe/activated carbon catalyst. Sep. Purif. Technol. 147: 179-185

9. Aljeboree AM. (2016). Adsorption of crystal violet dye by Fugas Sawdust from aqueous solution. Int. J. ChemTech Res. 9 (3): 412-423

10. Kyi PP, Quansah JO, Lee CG, Moon JK, Park SJ. (2020). The removal of crystal violet from textile wastewater using palm kernel shell-derived biochar. Appl. Sci. 10 (7): 2251. Available from: https://doi.org/10.3390/app10072251

11. Bernardino CAR, Mahler CF, Veloso MCC, Romeiro GA. (2017). Preparation of biochar from sugarcane by-product filter mud by slow pyrolysis and its use like adsorbent. Waste Biomass Valoriz. 8 (7): 2511-2521. Available from: https://doi.org/10.1007/s12649-016-9728-5

12. Vyavahare G, Jadhav P, Jadhav J, Patil R, Aware C, Patil D, Gophane A, Yang YH, Gurav R. (2019). Strategies for crystal violet dye sorption on biochar derived from mango leaves and evaluation of residual dye toxicity. J. Clean. Prod. 207: 296-305. Available from: https://doi.org/10.1016/j.jclepro.2018.09.193

13. Yang HI, Lou K, Rajapaksha AU, Ok YS, Anyia AO, Chang SX. (2018). Adsorption of ammonium in aqueous solutions by pine sawdust and wheat straw biochars. Environ. Sci. Pollut. Res. 25 (26): 25638-25647. Available from: https://doi.org/10.1007/s11356-017-8551-2.

14. Sewu DD, Jung H, Kim SS, Lee DS, Woo SH. (2019). Decolorization of cationic and anionic dye-laden wastewater by steam-activated biochar produced at an industrial-scale from spent mushroom substrate. Bioresour. Technol. 277, 77-86. Available from: https://doi.org/10.1016/j.biortech.2019.01.034.

15. Ahmad M, Lee SS, Oh SE, Mohan D, Moon DH, Lee YH, Ok YS. (2013). Modeling adsorption kinetics of trichloroethylene onto biochars derived from soybean stover and peanut shell wastes. Environ. Sci. Pollut. Res., 20 (12): 8364-8373. Available from: https://doi.org/10.1007/s11356-013-1676-z.

16. Sewu DD, Boakye P, Woo SH, (2017). Highly efficient adsorption of cationic dye by biochar produced with Korean cabbage waste. Bioresour. Technol. 224: 206-213, 2017. Available from: https://doi.org/10.1016/j.biortech.2016.11.009.

17. Wathukarage A, Herath I, Iqbal MCM, Vithanage M, (2019). Mechanistic understanding of crystal violet dye sorption by woody biochar: implications for wastewater treatment. Environ. Geochem. Health 41 (4): 1647-1661. Available from: https://doi.org/10.1007/s10653-017-0013-8.

18. Ahmadi M, Kouhgardi E, Ramavandi B, (2016). Physico-chemical study of dew melon peel biochar for chromium attenuation from simulated and actual wastewaters. Korean J. Chem. Eng., 33 (9): 2589-2601.

19. Kulkarni RM, Revanth T, Acharya A, Bhat PP, (2017). Removal of crystal violet dye from aqueous solution using water hyacinth: Equilibrium, kinetics and thermodynamics study. Resource-Efficient Technologies, 3: 71-77. Available from: https://doi.org/10.1016/j.reffit.2017.01.009.

20. Saha PD, Chakraborty S, Chowdhury S, (2012). Batch and continuous (fixed-bed column) biosorption of crystal violet by Artocarpus heterophyllus (jackfruit)leaf powder.

Colloids Surf. B Biointerfaces, 92: 262-270. Available from: https://doi.org/10.1016/j.volsurfb.2011.11.057.

21. Saeed A, Sharif M, Iqbal M, (2010). Application potential of grapefruit peel as dye sorbent: kinetics, equilibrium and mechanism of crystal violet adsorption. J. Hazard. Mater. 179 (1-3): 564-572. Available from: https://doi.org/10.1016/j.jhazmat.2010.03.041.
22. Kumar R, Ahmad R, (2011). Biosorption of hazardous crystal violet dye from aqueous solution onto treated ginger waste (TGW). Desalination. 265 (1-3): 112-118. Available from: https://doi.org/10.1016/j.desal.2010.07.040.
23. Chakraborty S, Chowdhury S, Saha PD, (2011). Adsorption of crystal violet from aqueous solution onto NaOH-modified rice husk. Carbohydr. Polym. 86 (4): 1533-1541. Available from: https://doi.org/10.1016/j.carbpol.2011.06.058.
24. Sahbaz DA, Dandil S, Acikgoz C, (2019). Removal of crystal violet dye by a novel adsorbent derived from waste active sludge used in wastewater treatment. Water Qual. Res. J. 54 (4): 299-308. Available from: https://doi.org/10.2166/wqrj.2019.049.
25. Saniya A, Sathya K, Nagarajan K, Yogesh M, Jayalakshmi H, Praveena P, Bharathi S, (2020). Modelling of the removal of crystal violet dye from textile effluent using Murraya koenigii stem biochar. Desalin. Water Treat. 203, 356-365. Available from: https://doi.org/10.5004/dwt.2020.26191.
26. Uphade BK, Thorat DG, Gadhave AG, Kadnor VA, (2011). Degradation of dye using CuS-CdS as a photocatalyst. Asian J. Research Chem. 4 (12): 1892-1894.