Decolorization of reactive red 2 dye by using pva-polyaniline immobilized system

Mohd Fairul Sharin Abdul Razak1,*, Mohd Nazry Salleh1, Azliza Azani1, Nurul Izzati Muhammad Zakir1
1School of Materials Engineering, Universiti Malaysia Perlis, (UniMAP), 02600 Jalan Kangar-Arau, Perlis.

Abstract. The immobilized of polyaniline (PANI) and polyvinyl alcohol (PVA) in bilayer system were studied base on several operational condition parameters such as loading and pH of the reactive red 2 dye solution. The PVA/PANI immobilized system was prepared by coating the PVA layer followed by deposition of PANi onto the surface of the glass plate. In this system, the addition of PVA particles works as binder between the PANi and the substrates. It was found that, PVA/PANI works as absorbent in this system and shown good response towards to the adsorption process of RR2 dye. This process can be seen by the decolorization of the dye. This decolorization was influenced by several factors which related to the interaction of dye with PVA/PANI composite and also during conditioning of dye as well. As a result, the adsorption process of RR2 dye in the immobilized system showed the best removal of dye under aerated system with the solution condition at pH 7. The percentage of dye removal was increased linearly with the amount of loading PVA/PANI. The rate of adsorption of dye was high at the beginning and after 30 minutes and onwards, all loading absorption rate has drop and the reading started to plateau indicates the surface areas of the system were nearly filled up by the dye particles. Thus, the highest adsorption was achieved was at 80% removal after two hours. Indeed, by prolonging the time did not change the colour of the solution indicated to the maximum adsorption capacity of the process has been achieved.

1 Introduction

Anionic dye in textile industry is widely use around the world especially for more than 50% mainly for cotton dye which has been introduced by ICI in 1950s commercially, due to its bright colors, various range of colour and shades to be used, good washing fastness and are easy to apply to the textile and products [1]. Unfortunately, the usage of this type of dye has contributes to another problem that cause effluent water pollution as the dyes have oxygen demand, colour, and salt load [2]. It is more difficult to remove the presences of the dye using conventional bio-systems as the complex and stable chemical structure of the anionic dye make them resistant to bio-degradation [1]. The common conventional methods to remove the synthetic azo dyes are ultrafiltration, extraction,

* Corresponding author : fairulsharin@unimap.edu.my
absorption and oxidation with ozone and hydrogen peroxide. Alternatively, photocatalyst can be used to treat the polluted effluent water by using advanced oxidation processes (AOP).

During photocatalyst process, adsorption process also occurs spontaneously before photocatalysis process taking place. The advantages of adsorption process are for its simplicity in operation, inexpensive (compared to other separation processes) and without sludge formation. Textile industries are the major consumers of water and they impart a reasonable amount of color in the effluent [3-4].

2 Experimental

Soluble polyaniline was synthesis by using emulsion polymerization technique [5]. While PVA solution was prepared based on the report [6] whereby the solubility of the PVA powder was improved by increasing the temperature of the solution. Thus, both layers were coated onto the glass plate with a dimension of 4.5 cm x 4 cm which form a bilayer PVA-PANI immobilized system. For the study of loading bilayer PVA/PANI, a series of different layers PVA/PANI were varied from 0.01, 0.03, 0.05, 0.07 and 0.09 g. The experiment to study the adsorption of the RR2 dye by PVA/PANI system was set up in the dark place. The RR2 dye solution was poured into the glass reactor cell, and then the glass plate was immersed into the reactor cell. The immersion of the PVA/PANI in the dye is set for 3 hours with interval every 30 minutes. The pH of the dye and the presence of aeration in the dye were also varied to study the efficiency of the absorption of dye by the PVA/PANI immobilized system.

3 Results and Discussion

3.1 Effect of PVA/PANI loading

The loading of PVA/PANI was varied from 0.01, 0.03, 0.05, 0.07 and 0.09 g immersed into the 30 ppm RR2 dye solution. By manipulating the loading of the PVA/PANI, the surface area available for the RR2 to adhere to PVA/PANI also varies which the heavier the PVA/PANI loading, more surface area available for adsorption [7]. From Fig.1, it shows that percentage of adsorption for set of loading has reached to 80% and more dye will be adsorbed removal after 90 minutes. At the first 30 minutes, the adsorption for all loading showed high rate of adsorption. This is due to the high surface area of the PANI available for RR2 dye to be absorbed. After 30 minutes and onwards, all loading adsorption rate has drop and the reading started to plateau.

As the time increasing, the surface area available for adsorption was reduced which make less dye being absorbed. 0.01 g loading has the lowest adsorption compared to other. This is due to less area available for dye to be absorbed by the PVA/PANI, followed by 0.03 and 0.05 g loading respectively. However most of the samples showed the same trend of adsorption after one hour and it started to slow down. Based on K value for each samples, 0.05 g loading slightly higher than 0.03 g loading which is 0.414 and 0.396 K min^{-1}.  


3.2 Microstructure Analysis

Microstructures of PVA/PANI bilayer were analysed through scanning electron microscope (SEM) at 1000 and 5000 times magnification with 20kV energy. The SEM images of PVA/PANI immobilized system before immersion in the RR2 dye has shown in Fig. 2. In Fig. 2(a), it shows that PANi has interaction with the PVA as PVA act as a binder to PANI for hold the PANI coated onto glass substrate. PANI is presence in the agglomerated form and was dispersed on the surface of the PVA phase.

From the Fig. 2(b), it shows the structure of PVA/PANI immobilized film at x5000 magnifications. The agglomerated structure of the PANI on the PVA phase provide more surface area for the removal of the dye as more dye can be deposited or reacted with the PANi upon immersion [8].

Fig. 1. The percentage of dye adsorption at different loading of PVA/PANI immobilized system.

Fig. 2. SEM images for annealed PVA/PANI bilayer at (a) 1,000 and (b) 5,000 magnification.
3.3 The aeration study

The effect of aeration study of PVA/PANi immobilized system toward RR2 dye was compared with the aerated immobilized system under the same experimental conditions. Both systems are using the same composite loading 0.05g with the concentration of RR2 is 30 ppm.

From the Fig. 3, it shows that the percentages of adsorption for both systems had reached 20 % difference just at 30 minutes contact time between aerated system and non-aerated system. Obviously, the aerated system had improved the adsorption process tremendously with nearly reached at almost 95% dye removal for 180 minutes while the non-aerated system only reach maximum 44% dye removal at the same time.

The main purpose of the aeration process is to supply the oxygen to the RR2 dye and fasten the process of the dye removal and aid the adsorption process by the PVA/PANi immobilized system [5].

![Fig. 3. The percentage of adsorption dye under aerated and non-aerated system.](image)

3.4 Effect of Different pH solution of RR2 Dye

The pH of the dye can affect the efficiency of the adsorption rate of the dye onto PVA/PANi immobilized film [7]. Fig. 4 shows the adsorption process by PVA/PANi immobilized film work the best at pH 7 which it remove almost 54% of the dye, followed by pH 3, 9, 5 and 11 with percentage of dye removal at 45%, 40%, 36% and 23% respectively after 180 minutes. In acidic condition, the dye absorption works the best in pH 3 as compared to pH 5. With the addition of H⁺ it helps the absorption to be more effective. Meanwhile, in alkaline condition, with increasing OH⁻ in the dye solution from pH 9 to pH 11, the absorption become inefficient, as the OH⁻ species limit the interaction between the RR2 dye and the PVA/PANi immobilized film [9-11]. Therefore, the PVA/PANi immobilized film in neutral condition at pH 7 shows the highest adsorption of RR2 dye which is more than 50%. This shows that, without interfering with addition of OH⁻ and H⁺, the RR2 dye adsorption by PVA/PANi immobilized system can occur in the optimum condition.
4 Conclusion

The effect of loading of PVA/PANI bilayer system was optimized while the effect of aeration study and pH value of RR2 dye was observed towards the adsorption process by PVA/PANi bilayer system. The PVA/PANi immobilized system works the best as the adsorption agent for removing the RR2 dye at optimum condition for more than 80% dye removed from the original dye concentration. The aeration process contributes to more efficient dye removal and the loading of the PVA/PANi works the best at 0.05g loading. Moreover, at pH 7 showed the adsorption process works the best for removing of the dye. Lastly, SEM image revealed that PVA works as binder hold tight the particles of PANI and also improved the adsorption process due to better contact of surface area with the dye.

The authors wish to gratefully acknowledge the School of Materials Engineering, as well as Research and Innovation Department under Universiti Malaysia Perlis and Kementerian Pengajian Tinggi Malaysia (Ref: FRGS/1/2019/STG01/UNIMAP/02/2) for supporting this research project.

References

1. J. Tie, X. Fang, X. Wang, Y. Zhang, T. Gu, S. Deng, G. Li, D. Tang, Pol. J. Environ. Stud. 26, (2017)
2. A. Khatri, M. H. Peerzada, M. Mohsin, and M. White, J. Clean. Prod., 87, (2015)
3. B. Ohtani, J. Photochem. Photobiol. C, 11, (2010)
4. B. Haspulat, A. Gülce, and H. Gülce, J. Hazard. Mater., 260, (2013)
5. D. Sivakumar, and D. Shankar. International journal of environmental sciences 2, (2012)
6. C. I. Awuzie, Mater. Today Proc., 4, (2017)
7. D. S. Patil, J. S. Shaikh, D. S. Dalavi, S. S. Kalagi, and P. S. Patil, Mater. Chem. Phys., 128, (2011)
8. R. Maas and S. Chaudhari, Process Biochem., 40, (2005)
9. K. M. Molapo et al., Int. J. Electrochem. Sci., 7, (2012)
10. S. K. Shukla, C. S. Kushwaha, and N. B. Singh, Mater. Today Proc., 4, (2017)
11. Z. A. Boeva and V. G. Sergeyev, Polym. Sci. Ser. C, 56, (2014)