Elimination of red Bimacid dye in aqueous solution by biosorption and adsorption

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Abstract

Dyes are generally believed to be toxic and carcinogenic or prepared from other known carcinogens. Apart from the toxicological properties of dyes, their color is one of the first signs of contamination recognized in a wastewater. The treatment of these effluents has become essential to reduce the potential toxicity of its pollutants and minimize their concentrations to the acceptable limits prior to their discharge. The experimental results show that the percentage of removal of dye by biosorption is more significant (90%) compared to adsorption where the rate of elimination did not exceed 60% on bentonite and pouzzolan powders. The kinetics of biosobtion and adsorption of the red dye bimacid on these materials showed great affinities adsorbent – adsorbate. The pH influenced positively the rate of elimination of the dye in the case of adsorption. On the other hand in the biosorption the pH became a limiting factor

Introduction

The removal of dyes from industrial wastewater is a problem of increasing concern. It has been mostly solved by chemical and physical treatment methods such as adsorption. However, these procedures have significant disadvantages, such as energy requirements, generation of toxic sludge, other waste products and are generally very expensive when the contaminant concentrations are in the range 10–100 mg/l (Ho YS et al.2000). Consequently, it is very important to use low cost methods and easily available materials, which could adsorb toxic dyes from wastewater. Microorganisms are potent bioremediators, removing dyes via active or passive uptake mechanisms.The effectiveness of these processes is usually dependent on the parameters such as temperature, toxicity, oxygen level and availability of nutrients.

The objective of this study is to compare between adsorption and biosorption efficiency applied to wastewater treatment from textile industry

Methods

– The biosorbent used in this study, was provided from the plant of domestic wastewater treatment. The microorganisms were grown in enriched media containing glucose (1 g/l) ; peptone of casein 0,2g /l; NH_4NO_3 , 0,0571g/l and to the final KH_2PO_4 , 0,35g/1

– Biosorption experiments were performed in a batch reactor placed in a rotary shaker at 100 rpm and 20°C. The solutions to be treated contain 10% (v/v) of inoculum rate. Grains of pouzzolan 30 mm in size and $4m^2.g^{-1}$ in area were used as a support. The samples were periodically centrifuged at 1000 rpm for 05 min and the supernatant liquid was separated and analysed for residual red bimacid concentration.

– Adsorption experiments were conducted in 300 ml batch reactor at 20°C containing 20 ml of red bimacid solution. 0.1g of bentonite and pouzzolan powder was used as adsorbents in all experiments. The removal efficiency (R_E) of each tested system and the dye uptake q(mg/g) was determined by the following equations:

$$E(\%) = \frac{(C_0 - C_t)}{C_0}.100 \quad Eq.(1) \; ; \; q_t = \frac{(C_0 - C_t).V}{m} \quad Eq.(2)$$

Where C_0 and C_t are the initial and final dye concentrations (mg/l), respectively; V is the volume of solution (ml), and m is the mass (g) of the adsorbents used.

Results and discussion

Figure 1,2 show an example of dye removal experiments using the different tested systems; in this case the initial red bimacid concentration was 40 mg/ℓ. The Dye removal rate of immobilized cells was slower than for those obtained by adsorption on bentonite and pouzzolan powders. However, the maximum red bimacid removal rate was obtained by biosorption. After 96 h the dye concentration is10 mg/ℓ, although in adsorption the red bimacid concentrations after 8 h were 21.66 and 20.33 mg/ℓ for pouzzolan and bentonite respectively. The results using different dye initial concentrations showed a similar tendency.

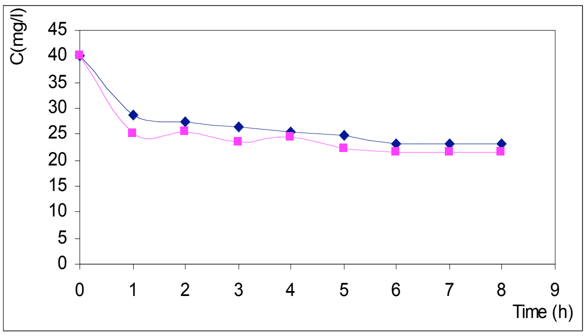


Figure 1: adsorption on bentonite and pouzzolan

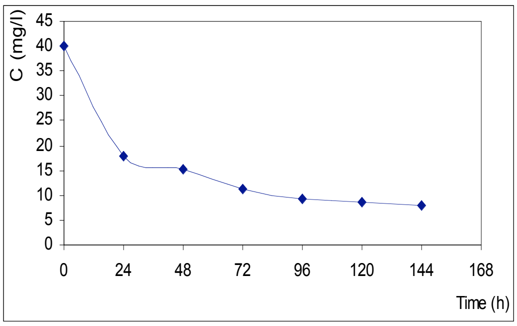


Figure 2: biosorption by immobilized cells

Effect of pH

The role of hydrogen ion concentration on the dye adsorption of bentonite and pouzzolan were examined at different pH in the range of 20–8.0. The results, shown in Fig.3, reveal that the red bimacid adsorption by two systems increased from47% to 71 % and 42% to 64 % respectively when the pH solution decrease from 6.0 to 2.0. The remarkable decrease in the residual concentration of dye reflects a significant reduction in the quantity of positive surface charge. At acidic pH, the negatively charged surface of bentonite and pouzzolan attracts negatively dye charged by columbic forces.

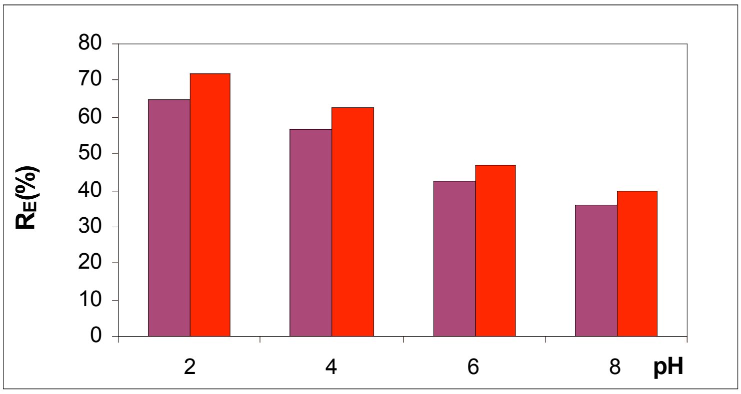


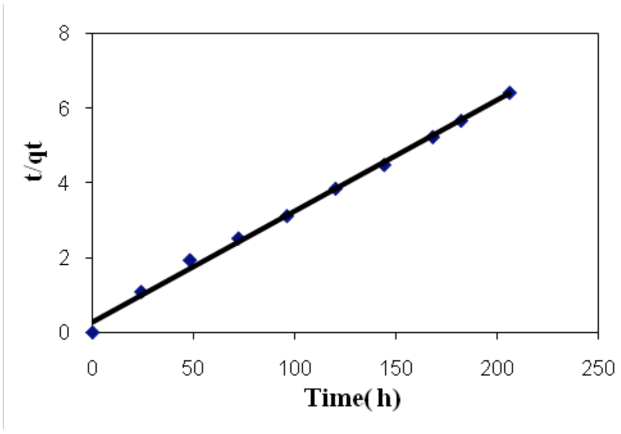
Figure. 3. Influence of pH

Adsorption and Biosorption kinetics

The kinetics of the adsorption data was analysed using two kinetic models, pseudo-first order and pseudo-second order kinetic models. These models correlate solute uptake, which are important in predicting the reactor volume. The possibility of adsorption data following Lagergren pseudo-first order kinetics(J.L. Wang and C. Chen ,2009)is given by Eq. (3). A pseudo-second order model, equation 4, proposed by (Reddad et al., 2002) is used to explain the biosorption kinetics.

$$\left[\frac{1}{(q_e - q)}\right] = \left[\frac{1}{q_e}\right] + k_2\, t \qquad Eq.(4)$$

$$-\mathrm{Log}_{10}\left[\frac{(q_e - q)}{q_e}\right] = \frac{k_1}{2.3} t \qquad \mathrm{Eq.}(3)$$



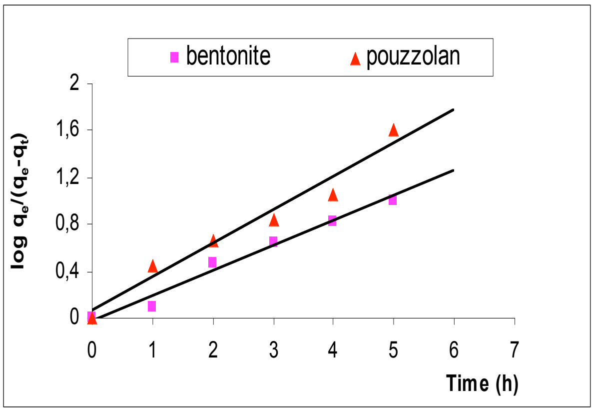


Figure 4. *Pseudo-first order kinetics for red bimacid onto bentonite and pouzzolan.(adsorbent size =100µm)*

Figure . 5. Pseudo-second order kinetics for dye onto immobilized cells

On figure.5, the linear regression and the higher value of R^2 = 0.99 values confirm that data are well represented by pseudo-second order kinetics and the biosorption is due to chemisorptions (Y. Prasanna et al.2006)

Conclusion

The present study showed that the biosorption by immobilized cells can be considered as an alternative technology for sequestering dye from textile effluent in batch process. The advantages of using this biosorption then adsorbent towards dye treatment are the simplicity of the required system and the ability. Maximum biosorption of red bimacid were observed at pH basic (82%). However the maximum adsorption were observed at pH=2.0. 74(%) . However, before this technology can be fully optimized for environmental applications, further study is needed. Important questions currently under investigation include the establishment of the exact mechanisms of biosorption by the cells, understand the dye transformations and the development of ways to enhance and stabilize the catalytic activity immobilized cells.

References

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