

RESEARCH ARTICLE

Synthesis and Characterization of Biaphehb/P(Aa-Co-Am)) Composites Hydrogels and their Kinetic Study as Adsorbent for Rhodamine 6g Dye from their Aqueous Solutions

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ABSTRACT

BIAPEHB/P(AA-co-AM)) composites were made using a free radical polymerization technique that included potassium persulfate (KPS) as a precursor and N, N'-methylene bisacrylamide (MBA) as a cross-linking agent. This study utilized the surface to extract Rhodamine 6G dye from its aqueous solutions. The time necessary for equilibrium was 45 minutes, which corresponds to when the peak adsorption value occurs. The surface was analyzed using field emission scanning electron microscope (FE-SEM), transmission electron microscopy (TEM), and fourier transform infrared spectroscopy (FTIR) techniques before and after the adsorption process. Also, ionic strength and pH experiments were conducted, experiments were conducted at pH 7 and 25°C. After completing the kinetic investigation on the adsorption process using pseudo-first and pseudo-second-order models, it was determined that the pseudo-second-order model ($R_2 = 0.9998$) is more consistent with the adsorption process of dye on the composites surface and that by correlation coefficients accreditation.

Keywords: Acrylic acid, Acrylamide, Adsorption, Benzimidazole derivative, Hydrogel composites, Rhodamine 6G.

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INTRODUCTION

Dyes are complex organic molecules utilized in a variety of industries and advanced technological disciplines, including textiles, paper, rubber, plastics, cosmetics, food, printing, dyes, leather tanning, and others.¹⁻³ These industries leave liquid waste loaded with dyes discharged into water bodies, which leads to the pollution of water nature with colors.^{4,5} Where color is the first pollutant to be identified, It is necessary to get rid of it in sewage water before throwing it into water bodies. Unwanted colors reduce sunlight penetration, as this affects the growth of bacteria and disturbs its biological activity.⁶⁻⁸ Also, dyes change chemically and biologically within the sewage water and consume the oxygen present in the aquatic environment.⁹ The dyes also attract metal ions that produce toxins for living organisms, including fish.¹⁰⁻¹²

For all of these problems mentioned above, many governments enacted strict laws, especially in developed countries that are distinguished by advanced industries, on industries that use colors in coloring their products.¹³ It stressed the need for serious and effective treatment of pollutants

in sewage water and not to throw them into environments and water bodies loaded with industrial chemicals and dyes.¹⁴ These has prompted intensive and diligent studies and experiments to treat water pollution and effluents. It has become clear and certain that removing such coloring agents from sewage and effluents is of great technical importance from the environmental and commercial side. Adsorption is a more effective wastewater elimination and treatment method due to its ease of use, low financial cost, and the possibility of reusing the materials used as adsorbents.^{15,16}

EXPERIMENTAL

Chemicals and Materials

Acryl amide (AM), Potassium Chloride, Sodium Chloride, the initiator potassium persulfate (KPS), and Calcium Carbonate were supplied by (Fluka Germany). Acrylic acid (AA), N, N'-methylene bisacrylamide (MBA), Rhodamine 6G, Glacial Acetic Acid, 4-amino-2-hydroxybenzoic acid, 2-mercaptobenzimidazole, and 4-Aminoacetophenone were purchased from (Sigma-Aldrich, Germany). Ethanol was supplied by (Himedia, India).

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Synthesis of Adsorbent (BIAPEHB) / P(AA-co-AM)

The organic reagent 4-((1-(4-((1H-benzo[d]-imidazole-2-yl) amino) phenyl) ethylidene) amino)-2-hydroxybenzoic acid (BIAPEHB) was synthesized from the reaction of 1 mmol of 2-mercaptobenzimidazole and 4-aminoacetophenone. The mixture was refluxed for 6 hours, wherein the compound A, which is 1-(4-(1H-benzo[d]imidazol-2-yl)) amino) phenyl) ethan-1-one. Then 1-mmol of each of compound (A) and 4-amino-2-hydroxybenzoic acid was taken. 4–5 drops from glacial acetic acid were supplemented to the clutter. For 12 hours, the mixture was refluxed. The (BIAPEHB/P(AA-co-AM)) composite was made were dissolving 3 g from acrylic acid and acrylamide in 5 mL of distilled water, then adding 0.1 g from (BIAPEHB) dissolved in 2 mL from absolute ethanol, then passing nitrogen for 60 seconds, then adding (MBA) and (KPS) to the reaction mixture, and then placing it in a water bath at 65°C for 45 minutes even finish the polymerization process.

2-3. Adsorption Isotherm

Specific concentrations of dye Rh6G were used and were within the (10–800 ppm) range, then (0.05 gm) of the composite was added for each (10 mL) from the solution the dye. Then it was put in the shaker device at speed (120 rpm) until equilibrium at (45) and at 25°C. After centrifugation (6000 rpm) for a period of (15 minutes) the absorbency of the solutions was measured by UV-vis spectroscopy. Using the equation (1) below, the amount of adsorbed dye was calculated.

$$q_e \text{ or } \frac{x}{m} = \frac{V(C_o - C_e)}{m} \dots (1)$$

Where:

x and m are the quantity adsorbed and weight of adsorbent (g), respectively, C_o : initial concentration, C_e : equilibrium concentration (mg/ L), V: volume of solution (L)^{17,18}

DISCUSSION AND RESULTS

Characterization

The composite's FT-IR spectra prepared before and after adsorption, as in Figure 1 shows the presence of significant overlap between the -OH and -NH bonds, as a wideband appears within the range of 3456 cm^{-1} . The aliphatic alkyl groups -CH₂ were also shown. Symmetric and asymmetric expansion oscillations are in the range 2956–2941 cm^{-1} . C=O carbonyl group in the carboxylic acid and the cross-linking agent causes the absorption band between 1656 and 1741 cm^{-1} . As for the band of absorption at 1732 cm^{-1} , it belongs to C=N group.^{19,20}

Figure 2 is the images of (BIAPEHB/P(AA-co-AM)) composite before and after the of dye adsorption, using the technique of FE-SEM to determine the morphology of the surface, where it is clear that the surface is rough, lumpy, and multi-layered. After adsorption, It shows the even distribution and the filling of all the grooves on the surface by the dye.^{17,21}

Observing the TEM images makes it clear that (BIAPEHB/P(AA-co-AM)) composite has an even and regular distribution

of its constituent particles. The surface is also composed of layers and the presence of some lumps. After adsorption, clumps of larger size appear, and the layers disappear,²¹ as in Figure 3.

It revealed the results that (45 minutes) was necessary to get the greatest adsorption value, as explained in Figure 4. At 25°C, the dye was 200 ppm, and the surface weight was 0.05 g.

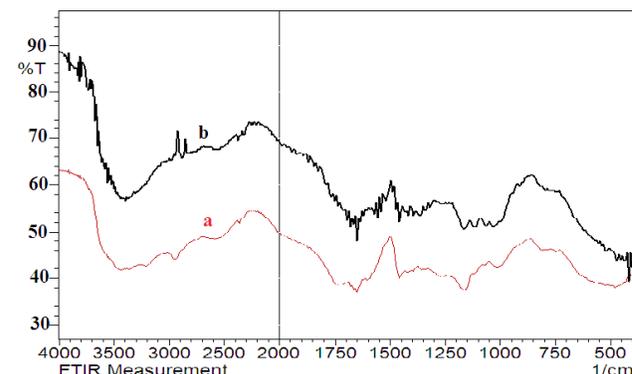


Figure 1: FTIR spectrum of (a) (BIAPEHB/P(AA-co-AM)) composite . (b) Composite after adsorption of (Rh6G) dye

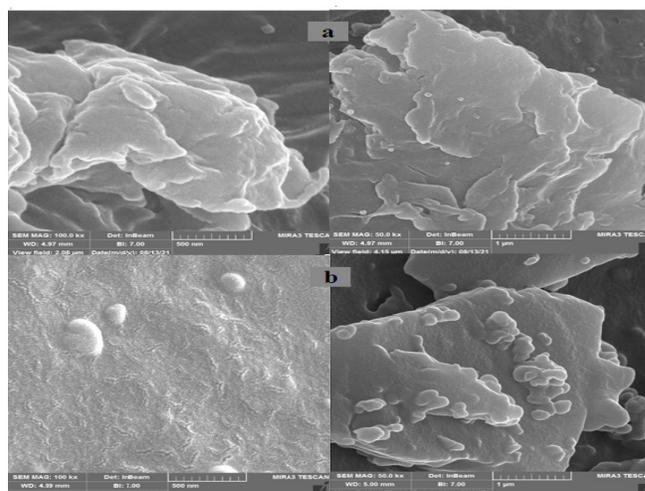


Figure 2: FE-SEM image of (a) (BIAPEHB/P(AA-co-AM)) composite . (b) Composite after adsorption of (Rh6G) dye.

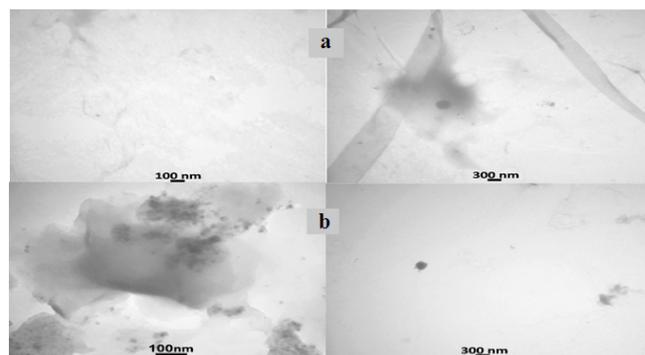


Figure 3: TEM image of (a) (BIAPEHB/P(AA-co-AM)) composite. (b) Composite after adsorption of (Rh6G) dye

The results also showed that adsorption increases at raised pH values, as shown in Figure 5a. And that It goes back to competition for active sites on the surface between H + ions and positive molecules of dye, thus decreasing adsorption at reduction pH value. When the pH values rise, the carboxylic and hydroxyl groups will ionize and turn into negative charges as the attraction between these groups and the dye molecules occurs. The value of (pH=7) was fixed for all experiments. As shown by Figure 5b that adsorption increases with increasing ionic strength, a group of salts was used for this purpose (CaCO₃, KCl, NaCl) with the stability of all experimental conditions.²²⁻²⁴

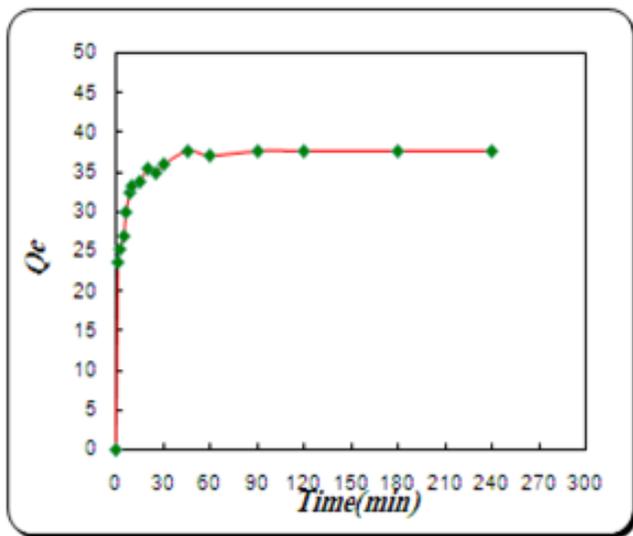


Figure 4: Contact time effect on (Rh6G) dye adsorption

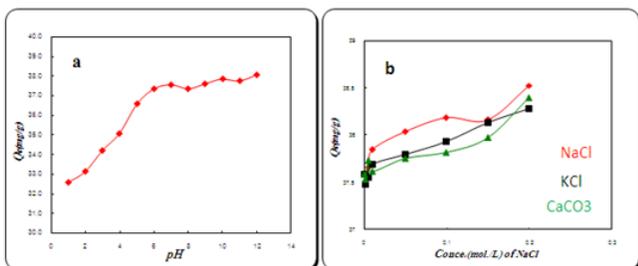


Figure 5: (a) Effect of pH values (b) Effect of ionic strength

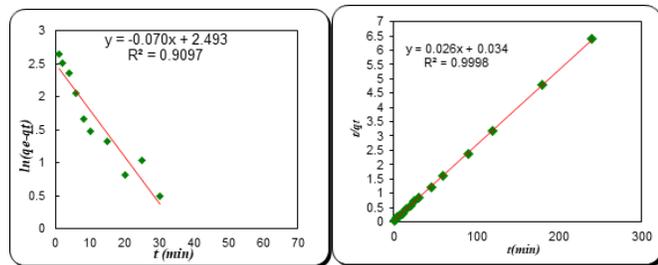


Figure 6: (a) pseudofirst-order model, (b) pseudosecond-order model

Table 1: Thermodynamic adsorption parameters (CV) on the composite

Pseudo- first order			Pseudo- second order			
k ₁ (min ⁻¹)	q _e (mg/g)	R ²	k ₂ (g. mg ⁻¹ .min ⁻¹)	q _e (mg/g)	R ²	h (mg. g ⁻¹ .min ⁻¹)
0.0723	12.0975	0.9097	0.0198	38.4615	0.9998	29.4117

The examination of the pseudo-first and second-order models is shown in Figure 6. Table 1 shows the correlation coefficients and kinetic constants for the adsorption process. The pseudo-second-order model, as compared to the pseudo-first-order model, provides a superior fit for the adsorption process due to the high value of (R²).^{23,24}

CONCLUSIONS

The adsorption of (Rh6G) dye from its aqueous solutions was studied on the (BIAPEHB/P(AA-co-AM)) composite surface. The results proved through (FE-SEM-TEM) measurements that the composite has a high ability to remove the dye. The study also discovered that when the pH and ionic strength of the solution increased, so did the surface’s adsorption capability. Also, the adsorption process obeys the pseudo-second-order model (R² = 09998).

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