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To cite this article: Noor Mustafa Kamal et al 2018 IOP Conf. Ser.: Mater. Sci. Eng. 454 012122

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Removal of Alizarin yellow dye from aqueous solution by adsorption on the pomegranate crusts

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Abstract. The aim of this research was to preserve the natural materials in the removal of organic or inorganic pollutants, where the study of removing Alizarin yellow dye from its water solution using pomegranate treated as chemically, the best time of adsorption was 45 minutes and the best weight of adsorption is 0.9 g which gave the rate of adsorption and the effect of some functions, including acidic function, temperature and isothermal adsorption, was studied. as for this interaction.

Keywords. adsorption, alizarin yellow, pomegranate crusts, Langmuir, Freundlich

1. Introduction

Despite the urgent human need for water, and its relation to the survival and purity of water, it has not been improved, however, by the increase in agricultural and industrial population activities near the source of this water, which has reduced its natural and chemical properties. The concentration of many pollutants in this water. The dyes are widely used in textiles, paper, plastics, foodstuffs and cosmetic industries. The disposal of these dyes in the environment with wastewater is a major cause of the pollution that is treated as a vital task. There are different ways of removing dyes from them [1-3].

Adsorption is the most versatile and widely used technique, Adsorption is a phenomenon that combines gas or liquid matter with molecules, atoms or ions on the surface of another solid material, which is different from absorption, a penetration of the crystalline structure of the solid matter. In this work, pomegranate crusts were used to remove the yellow pigment of isarin. Alizarin yellow pigment is used for dyeing wool and nylon [4]. It is a rust-solid material, usually in the case of pure sodium salt [5]. Its molecular formula is $C_{13}H_8N_3NaO_5$ (Na salt); its molecular mass is 309.21 g mol$^{-1}$ and its $\lambda_{\text{max}}$ is 370 nm. It is a slightly brown powder soluble in cold water. The damage of this dye irritates the eyes, skin, gastrointestinal tract, and respiratory tract. This study also includes the calculation of balance and motor coefficients. In addition, Langmuir, Freundlich, Temkin, Harkin-Jura, and Halsey isotherms were studied in detail [6].
2. Materials and Instrumentation
Alizarin yellow R $C_{13}H_{8}N_{3}NaO_{5}$, pomegranate crusts, Sodium hydroxide NaOH, Hydrochloric acid HCl, distilled water, UV-Visible Spectrophotometer (double Beam UV-Visible 1650 PC), Digital balance (monogement system, ISO.9001, Garmany), pH meter, Water bath vibrator (GFL 1083), Centrifuge.

2.1 Adsorbent
Pomegranate crusts were first washed with double-distilled water and dried in an oven at 70°C for 24 hours. The dried pomegranate crusts were broken, then boiled with distilled water for two hours at the boiling point. They were then filtered. This process was repeated to get rid of all the colored or soluble materials, after which it was filtered and dried.

At room temperature, an unspecified volume of H2SO4 with a concentration of 2 was added to the dried pomegranate. After 2 hours the filtration process was completed. Remove excess acid by washing the solid residue, repeatedly with distilled water until the remaining material is free of acid, and then drying the product at room temperature.

The produce thus prepared was kept in hot air oven at 110°C for 8 hours. For the purpose of obtaining a fine powder from the treated surface, Activated activated carbon has been activated to obtain after processing pomegranate crusts [7].

3. Results and discussion

3.1. Preparation of solutions
Different concentration solutions were prepared from Alizarin yellow R dye a 500 mL, and the absorption of these concentrations at the maximum wavelength was calculated to (370 nm) calculate the standard calibration curve, as shown in the figure (2) below.
3.2 determining the best adsorption time

For the purpose of finding the best time for adsorption of Alizarin yellow R dye on the surface of pomegranate peel, take 10 samples of the dye each sample containing 20 ml of the water solution of the dye mentioned in the concentration of 15 and 0.1 g of Adsorbent and placed in the water bath at 25, every 5 minutes withdrawn Sample and for 60 minutes and it was observed from the results that the best adsorption time is 45 min as figure (3) . The percentages of AY removal is calculated based on the following equation:

\[
\text{Dye adsorption (\%) = } \frac{(C_0 - C_e)}{C_0} \times 100
\]

In the above equation, \(C_0\) represents the concentration of the initial dye (before mixing with the adsorbent), and \(C_e\) represents the equilibrium concentration (after mixing with the adsorbent). By drawing a curved calibration of the AY dye where the concentration of the balance was obtained [8].

3.3 Influence of weight

The effect of the weight of the adsorbent was studied on the adsorption process. The adsorption was carried out for 45 minutes using 20 mL of the water solution of Alizarin yellow R dye at a concentration of 15 ml and different weights of surface A were added. All experiments were placed in a water bath at 25,(0.9 g) is the best weight of chemically treated pomegranate crusts.
Figure 4. Effect the weight of the adsorbent on adsorption Alizarin yellow R dye

3.4. Influence of pH.

Figure (5) shows the effect of pH on adsorption Alizarin yellow R dye. The effect of the acidic function on the adsorption of the dye on the surface of the pomegranate crust was studied within a range (4-8) at 25 °C using different concentrations (5-25) ppm, where the natural acidic function of the dye was 7. As shown in Figure Below, The highest adsorption rate in acidic function (4) Figure 1 shows that the highest adsorption rate occurs in the acidic function 4, ie, the absorption is lower. At 7 and 8, the adsorption ratio decreases. This increases the absorbance. Adsorption increases.

The lower the absorption capacity, the less the adsorption is due to the visit of negative sites where the effectiveness is less, so must maintain the least ph (ie in the center acid), which can remove that dye [10-11]

Figure 5. Effect of pH on adsorption Alizarin yellow R dye

3.5 Isotherm studies

Adsorption Isotherms or equilibrium data are helpful to describe the sorption interaction and adsorption capacity of adsorbent. For the purpose of the study of Isotherm Alizarin yellow R pigment on the surface of pomegranate, different concentrations of the dye mentioned above were obtained, with 20 ml of each concentration added to 0.9 g of surface and placed in a water bath vibrating for 45
minutes at 25 °C. After the adsorption period was finished, the absorption of the samples was measured at the maximum wavelength of the dipstick, and then the amount of adsorption was calculated. and the equilibrium concentration (Ce) and determine the adsorption isothersms dye on pomegranate peel carbon by plotting a graph between extent of adsorption (log q) and equilibrium concentration log Ce [12]. The relationship between log q and log Ce is called Freundlich adsorption isotherm. The logarithmic equation for Freundlich adsorption isotherm is given by following expression;

\[
\log q = \log K_f + 1/n \log Ce \quad (2)
\]

Where Kf and 1/n are Freundlich constants related to adsorption capacity (L/mg) and adsorption intensity respectively. A plot of log qe versus log Ce (Figure 6) was used to calculate the value of Kf and 1/n from intercept and slope respectively. These values are given in table 3.

![Figure 6. Freundlich adsorption isotherm for Alizarin yellow R dye](image)

Then graphically between ce vs. ce / q as in the figure, where the relationship between ce and ce / q is called The Langmuir adsorption isotherm [3]. The chemical equation for Langmuir adsorption isotherm is given by following expression.

\[
\frac{C_e q}{Q} = \frac{1}{Qb} + \frac{Ce}{Q} \quad (3)
\]

Where:

Ce is the equilibrium concentration of dye (mg/L); qe is the amount of dye adsorbed at equilibrium (mg/g); Q0 (mg/g) and b (L/mg) are the Langmuir constants. The plot of Ce/qe versus Ce (Figure 7) gives straight line (R2=0.995). The slope and intercept of the plot were used to calculate the values of Q0 (mg/g) and b respectively, which are given in table 1.
Figure 7. Langmuir adsorption isotherm for Alizarin yellow R dye

Table 1: Langmuir, Freundlich and Temkin adsorption constants of Alizarin yellow R dye onto pomegranate crusts

| Parameter                  | Langmuir adsorption isotherm | Freundlich adsorption isotherm |
|----------------------------|-------------------------------|---------------------------------|
| Q                          | 0.1811                        | -0.677                           |
| b                          | 0.1135                        | 0.607                            |
| R^2                        | 0.9519                        | 0.9657                           |

3.6 Influence of temperature

The effect of temperature on the process of adsorption of Alizarin yellow R dye on pomegranate crusts was studied within the range (298-318) K and Figure (8) illustrates the effect of this function, and note from the above figure , When the temperature increases, the adsorption process increases, the efficiency of the adsorption means that the process is endothermic[13].

Figure 8. Effect of temperature on adsorption Alizarin yellow R dye
According to the Vant Hoff equation, the relationship was drawn between \( \log X_m \) and \( 1/T \). As in the following Figure (9) the Vant Hoff equation for Alizarin yellow R dye for the purpose of calculating \( \Delta H \) [14]. Regulated thermodynamic functions such as the Gibbs free energy (\( \Delta G \)) function, and entropy (\( \Delta S \)) were also calculated using Eqs. (6) and (7), and in the Table (2) below shows the results obtained.

\[
\Delta G = -RT \ln k \quad (4)
\]
\[
\Delta G = \Delta H - T \Delta S \quad (5)
\]

Figure 9. The Vant Hoff equation for Alizarin yellow R dye

### Table 2: Thermodynamic parameters.

| Adsorbate            | \( \Delta G \) (kJ mol\(^{-1}\)) | \( \Delta H \) (kJ mol\(^{-1}\)) | \( \Delta S \) (J mol\(^{-1}\) K\(^{-1}\)) |
|----------------------|-----------------------------------|----------------------------------|---------------------------------------------|
| pomegranate crusts   | 5.079 kJ mol\(^{-1}\)           | 2.052 J mol\(^{-1}\)            | 17.03 J mol\(^{-1}\) K\(^{-1}\)            |

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