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Green Chemistry for Removing Brilliant Blue Dye

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ABSTRACT

The peels and pulp of Iraqi eggplant available in local markets were used as a surface in this work to remove the brilliant blue dye (BBD) from its aqueous solutions. Through work, the adsorption Isotherms and the factors affecting the adsorption process were studied, such as concentration, temperature, time and ionic strength. 0.2 g of surface in 50 ml of solution was used as a constant weight for the surface during work with a contact time of a quarter of an hour due to the short time required to reach equilibrium between the surface and the dye.

The results showed that the adsorption to remove dye on the surface of the peels is more than in the pulp. The removal of dye was studied at different temperatures, which were as follows (293K, 303K, 313K, 323K) for both surfaces, All experiments were at a pH = 7.

The Vat Hoff equation was applied to both surfaces, the thermodynamic functions ΔG, ΔH, ΔS were calculated, respectively, all the values of the thermodynamic functions were negative.

It was found that the adsorption process of the peels and pulp (exothermic) and (spontaneous). The addition of sodium chloride salt at a temperature of 20°C had an effect of decreasing adsorption more than its absence for both surfaces. The desorption at a temperature of 70°C were studied for the peels and the pulp.

The results showed that peels as a surface had more dye removal than the pulp surface.

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1. INTRODUCTION

Dyes are organic compounds that cause water pollution and are used in many industries, including the textile industry, petroleum industries, coloring and photography. [1] Many industries release dyes into wastewater, most of which cause skin irritation, reduce photosynthesis and prevent light penetration [2]. Discharging these dyes into water poses a toxic risk to human health, so dye pollutants must be removed from water [3]. Treating water polluted with dyes is one of the most important environmental issues that must be solved and eliminated [4]. There are many methods to remove dyes from polluted water, adsorption is the most commonly used method due to its low cost. [5] The accumulation of synthetic dyes has a harmful effect on the environment, a carcinogenic effect and many metabolic and genetic problems when used in large quantities [6]. Water polluted with dyes is treated in various ways, including ion exchange, decomposition, sedimentation, photo oxidation and Nano filtration [7]. Dyes are water-soluble substances due to the chromophore groups in their structural composition, especially reactive, direct, acidic and basic. [8]. Biological treatment is a suitable and environmentally friendly option in terms of cost to remove many types of organic and inorganic toxins [9]. The adsorption technique is characterized by effective dye removal by binding dye molecules to the surface of absorbent materials, and here the interest in using inexpensive and available surfaces has become very important [10]. Some studies deal with eggplant pulp as a source of phenolic acids, and only a few deal with eggplant peels [11]. Eggplant peels are an important source of biological compounds because they have antioxidants and anti-pathogenic properties [12]. The blue pearlite dye

has been widely used in textile industries, including silk, nylon and wood, as it gives stable and bright colors [13]. Many studies have used biomass such as (palm blossom, peanut shells, coffee shells, coconut pulp, mango seed kernels, etc.) as a low-cost adsorbent material to remove colors from polluted water [14].
The most common source of pollution in water is the dyes emitted from the pulp and peels, which are disposed of in the water [15]. Eggplant (pulp and peels) is used as an adsorbent surface in many studies, such as the removal of lead [16], oil, activated carbon and various nanomaterials [17,18]. Many research and studies have used different surfaces to remove dyes, such as the manufacture of matrix membranes made of eggshells and their integration with silica [19], the use of metal nanoparticles such as gold and platinum [20,21]. There are many searches studying the removal of brilliant blue dye on different surfaces [22,24]. In this work the peels and pulp of Iraqi eggplant are used. As an effective bio adsorbent for removing brilliant blue dye.

2. EXPERIMENTAL PART

2.1 Material: Fresh eggplants, Brilliant blue dye, Sodium Chloride

2.2 Instruments: Shaking water bath, Centrifuge, (Size 75 µm) Sieves, Daihan Labtech Oven LDO – 060E, **UV-Vis. spectrophotometer double beam, shimadzu1800**

2.3 Methods:

- Fresh eggplants were purchased from Iraqi origin and washed with water to remove dirt, then peeled
  the eggplant fruits, spread the peels and pulp and left for a week, then dried in a thermal oven, then ground with a sieve of diameter (75) µm and packaged for work.
- The brilliant blue dye, sodium chloride and distilled water were used, Figure 1.

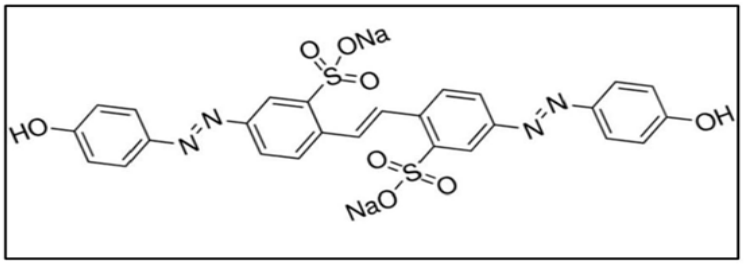

Figure 1. Shows the structural formula for the brilliant blue dye.

- Ultraviolet and visible spectroscopy techniques were used to determine the absorption concentration. The absorption wavelength of the bright blue dye was (621) nm. As shown in Figure 2.
- A stock solution of the dye was prepared at a concentration of (250) ppm, and other concentrations were prepared by dilution (5, 10, 15, 20, 25, 30) ppm.
- Six solutions of the dye at a certain concentration were placed in 50 ml flasks, 0.2 g of the surface was added to the flasks, and they were all placed in a shaking water bath. Samples of the concentration were taken at different times to calculate the equilibrium time, which was found to not exceed half an hour.
- The previous step was repeated by placing different concentrations with the surfaces for half an hour, after which they were separated from the surfaces by centrifugation to calculate the amount of adsorption on the surface using UV-visible spectroscopy.

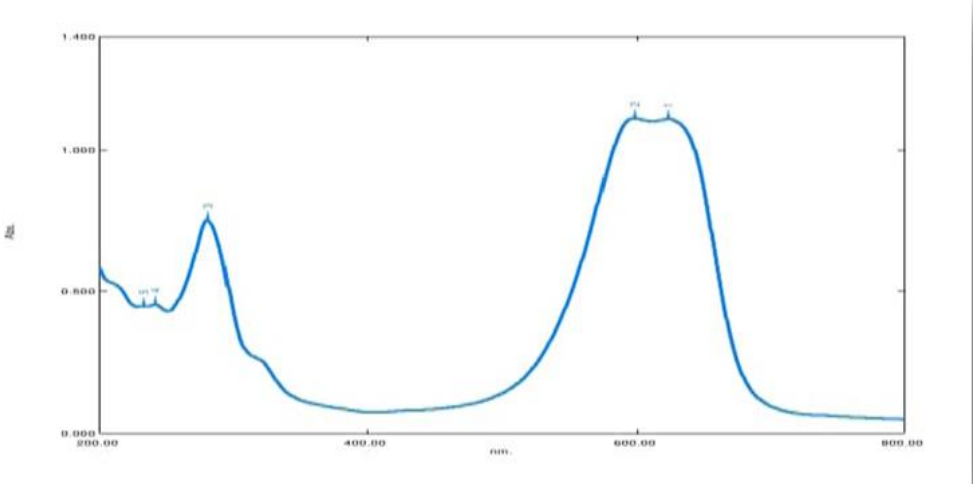

Figure 2. Shows the UV-visible spectrum absorption of the brilliant blue dye.

3. RESULTS AND DISCUSSION

3.1 Adsorption isotherm

The adsorption amounts were calculated according to the following equation [25]

Qe=(Co-Ce) V/m ……. (1)

Qe= the quantity of adsorbate(mg/g).
V= volume of solution (L).
Co= initial concentration (mg/L).
Ce= equilibrium concentration(mg/L).
m= mass of the surfaces(g).

We repeated the previous step to find out the absorption of the brilliant blue dye on the surface at different temperatures, where the adsorbed amount (Qe) was calculated and Qe was plotted against Ce. The general diagram for the adsorption of the brilliant blue dye on the surface of the peels and pulp showed that it is the (S3) class according to the (Gilles) classification [26] where the direction of the material molecules on the surface is vertical as in the following Figures(3, 4) for both surfaces of the peels and pulp.

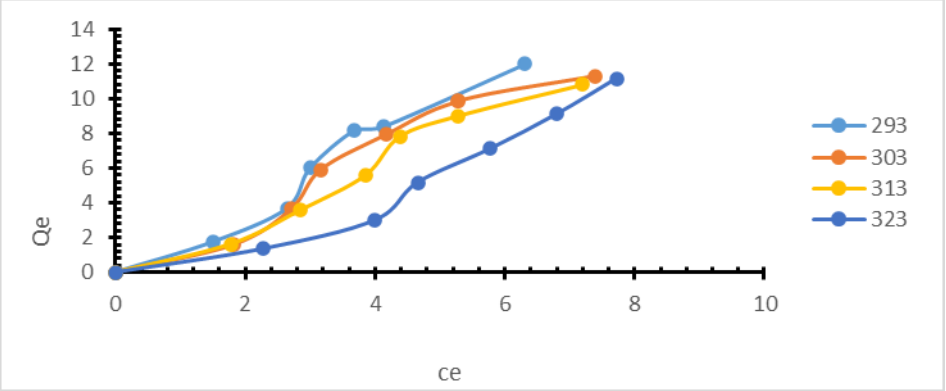

Figure 3. Adsorption isotherms of BBD on to the surface of the peels.

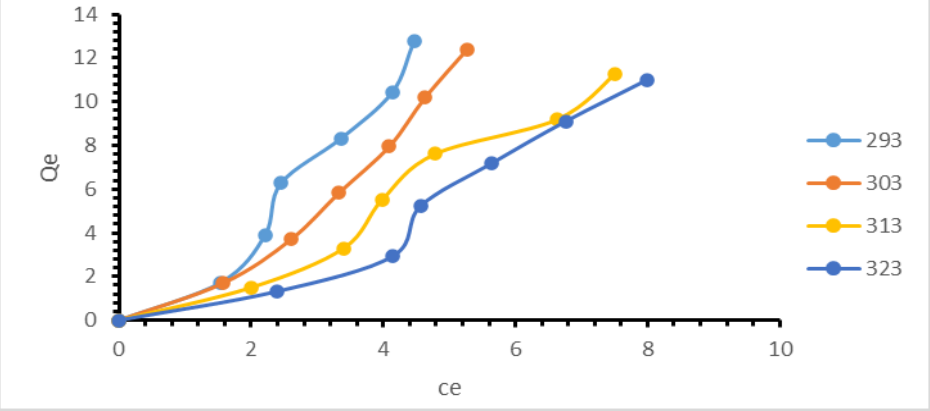

Figure 4. Adsorption isotherms of BBD on to the surface of the pulp.

The linear graph of the Tamkin adsorption equation [27]:

Qe = bT LnkT + bT LnCe) ……. (2)

Qe= the quantity of adsorbate(mg/g).
bT=the Temkin constant
kT = the equilibrium binding constant (L/g).
Ce= equilibrium concentration(mg/L).

It is more acceptable for matching the results than the other Freundlich and Langmuir equations as shown in Figure 5.

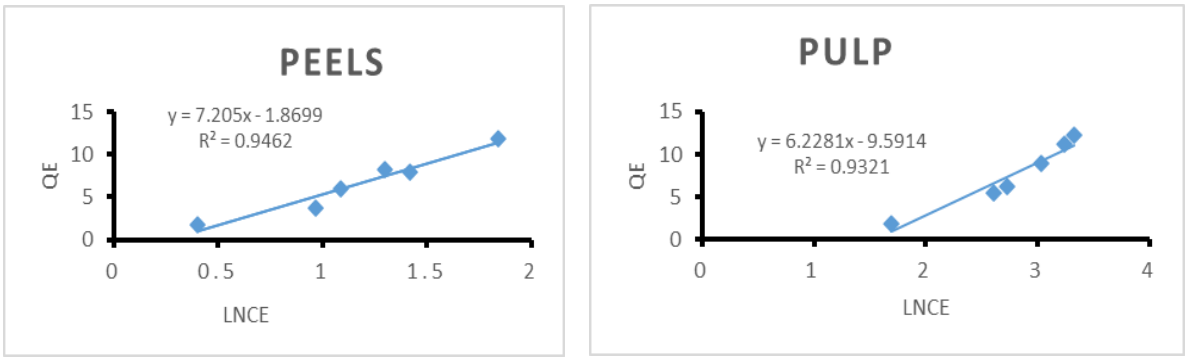

Figure 5. Shows the linear Tamkin adsorption equation for the peels and pulp

Values of the adsorption coefficients of Temkin equation for the brilliant blue dye for pulp and peel as shown in Table 1.

Table 1. Tamkin constants for adsorption on the peels and pulp

	b_T	k_T
peels	7.205	0.771
pulp	6.228	0.214

3.2 Thermodynamic studies of removal

The results showed that the amount of adsorption decreases with increasing temperature. Enthalpy was calculated by Van't Hoff-Arrhenius equations [2]:

$\ln Q_{max}=(-\Delta H)/RT+$ Constant ……. (2)

lnQmax was plotted against the temperature as shown in Figure 6(a-b) for both surfaces

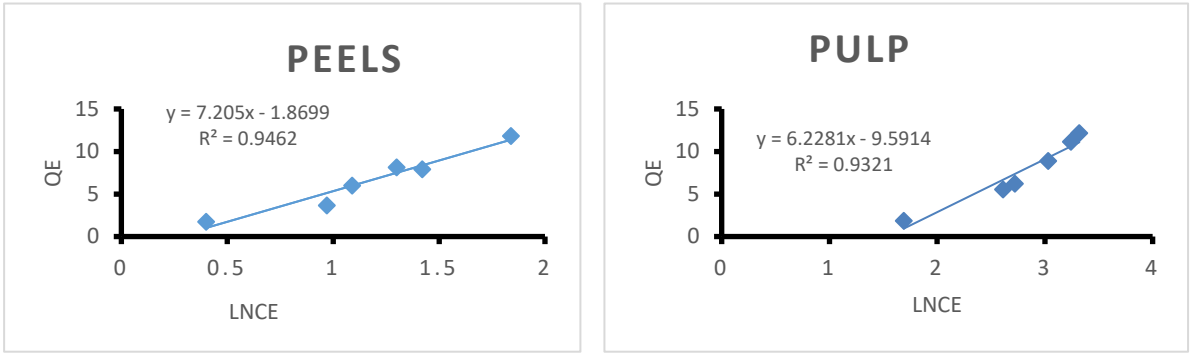

Figure 6(a-b). Vant Hoff curves for adsorption of BBD dye on both surfaces

Other thermodynamic functions were calculated using the following equations [1]:

$\Delta G^o=-nRT \ln Q_{max}$ …… (3)

$\Delta G^o= \Delta H^o- T\Delta S^o$ …….. (4)

Table 2. Thermodynamic functions for BBD adsorption on the peels.

T(K)	ΔH KJ/mol	ΔG KJ/mol.K	ΔS J/mol.K
293	-7.73	-6.016	-5.85
303		-5.794	-6.39
313		-5.751	-5.751
323		-5.505	-6.88

Table 3. Thermodynamic functions for BBD adsorption on the pulp

T(K)	ΔH KJ/mol	ΔG KJ/mol.K	ΔS J/mol.K
293	-16.96	-6.16	-37
303		-5.11	-39
313		-5.02	-38
323		-4.18	-40

From the Tables (2 and 3) above, the values of the enthalpy, entropy and compression energy functions are shown, respectively, as negative values, they are exothermic and spontaneous at all temperatures.

3.3 The effect of salt

The results showed that the presence of salt {sodium chloride 0.1 gr (0.034M)} decreased the adsorption and removal efficiency of the dye on both surfaces, as shown in Figure 7.

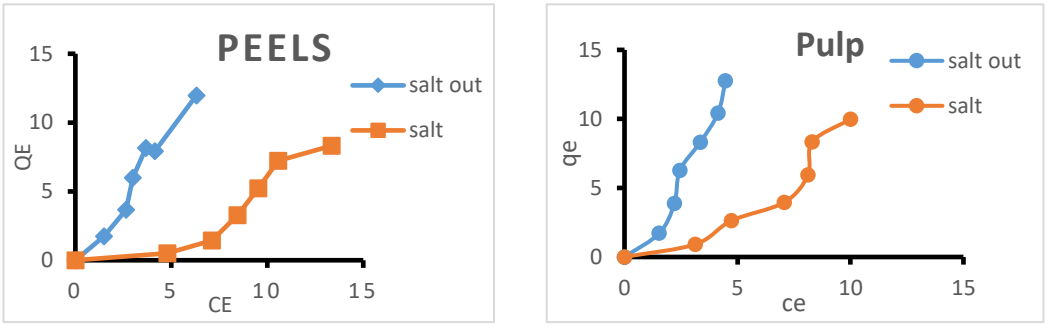

Figure 7. Shows the salt effect at a temperature at 293 K for peels and pulp.

3.4 The percentage of removal

The percentage of removal was calculated for all concentrations using the equation:

% removal=initial Conc. - residual conc./initial conc. ×100

The concentration ratio of dye removal is higher than the low, unlike the high concentration. At the lowest concentration, the surfaces do not reach the maximum dye capacity because their ability to absorb a large amount of dye and the remaining concentration is low. However, the surface at the high concentration reaches the maximum capacity, so the remaining concentration is high, Figure 8.

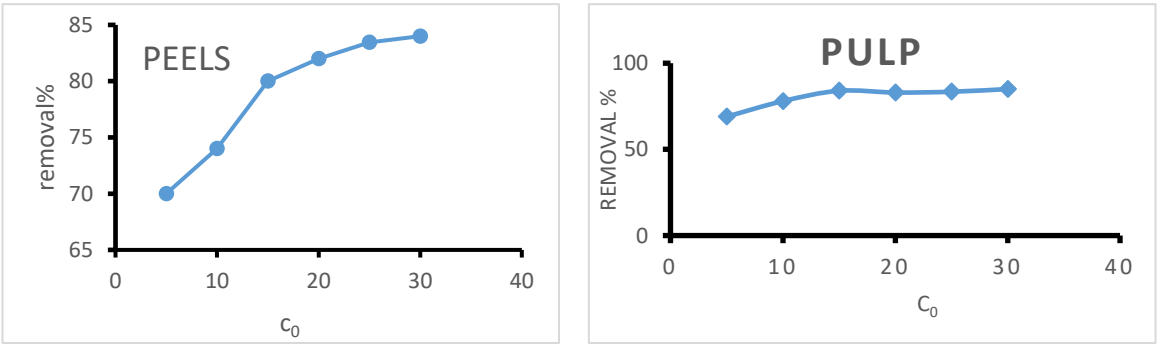

Figure 8. The removal ratio of the surfaces at 293K.

3.5 Desorption

The results showed that there is a possibility of recovering part of the dye from the surfaces at high temperatures, the desorption was studied at a temperature of 70ºC, as shown in Figure 9.

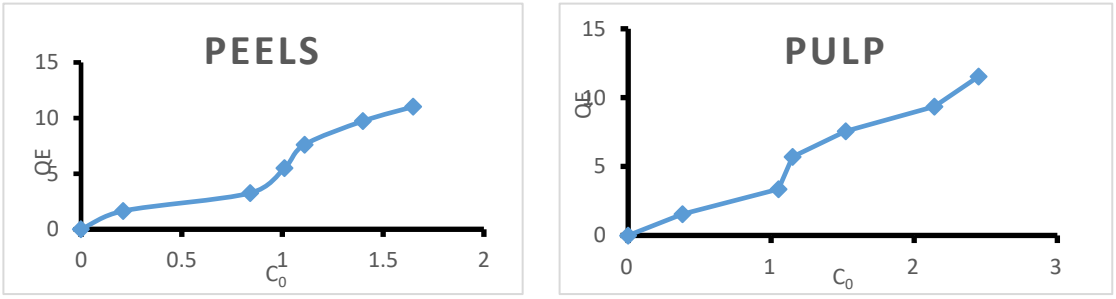

Figure 9. The desorption isotherms of BBD for both surfaces.

4. CONCLUSION

The study concluded that the peels and pulp of Iraqi eggplant can be used to remove brilliant blue dye to a certain extent and that temperature has a negative effect on the adsorption of the dye. It was also found that the presence of salt also has a negative effect on the adsorption. Part of the dye adsorbed on the surface of the peels and pulp can be returned to the solution again.

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CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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ETHICAL CLEARANCE

Ethical approval was not required for this study as it did not involve human or animal subjects.

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