Open Access
Baghdad Science Journal **Vol.14(1)2017**

DOI: http://dx.doi.org/10.21123/bsj.2017.14.1.0167

Adsorption of Congo Red Dye from Aqueous Solution onto Natural and Modified Bauxite Clays

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Received 7/3/2016
Accepted 21/ 6/2016

Abstract:

The adsorption behavior of congo red dye from its aqueous solutions was investigated onto natural and modified bauxite clays. Both bauxite and modified bauxite are primarily characterized by using, FTIR, SEM, AFM, and XRD. Several variables are studied as a function of adsorption including contact time, adsorbent weight, pH, ionic strength, particle size and temperature under batch adsorption technique. The absorbance of the solution before and after adsorption was measured spectrophotometrically. The equilibrium data fit with Langmuir model of adsorption and the linear regression coefficient R^2 is found to be 0.9832 and 0.9630 for natural and modified bauxite respectively at 37.5°C which elucidate the best fitting isotherm model. The general shape of the adsorption isotherm of congo red on natural and modified bauxite is consistent with (H-type) on the Giles classification. Different thermodynamic parameters such as Gibb's free energy, enthalpy and entropy of the on-going adsorption process have also been evaluated. The thermodynamic analyses of the congo red adsorption on natural and modified bauxite indicate that the systems are endothermic in nature.

Key words: Adsorption, Congo Red Dye, Langmuir Model, Freundlich Model, Thermodynamic Function, Bauxite, Modified Bauxite**.**

Introduction:

Dyes are considered as a type of colored organic substances. They are usually present in the effluent waste water of several industries, including textile, leather, paper, rubber, plastics, printing, cosmetics, pharmaceuticals and food industries. They contribute to water pollution, toxicity and represent an increasing danger for the environment, aquatic life, human and animals [1, 2]. Dyes usually have complex aromatic molecular structures which make them more stable and difficult to biodegrade. Furthermore, many dyes are toxic to some microorganisms and many cause direct destruction or inhibition of their catalytic capabilities [3, 4]. Usually, for color removal, the chemical and physical treatment techniques are more effective compared to the biological process; however they use more energy and chemicals. Several successful treatment technologies have been widely applied including ion exchange treatment,coagulation, precipitation, co-precipitation, oxidation, electro chemical technologies and adsorption [5, 6].The adsorption process is an attractive and effective alternative treatment for dye removal from waste water [7, 8]. Clays are hydrous aluminosilicates composed of mixtures of fine-grained clay minerals and metal oxides. Clays play an important role in the environment by taking up cations and anions through adsorption [9]. Bauxite is used for adsorption of dyes; it is the world´s main source of aluminum. It mostly consists of gibbsite, boehmite and diaspore, mixed with the two iron oxides goethite and heamatite in addition to the clay mineral kaolinite and small amounts of anatas TiO_2 [10]. The aim of the present study is the removal of congo red dye contamination from water by adsorption using natural and modified bauxite surfaces.

Materials and Methods

Apparatus

1. UV-Visible spectrophotometer, Double beam,Shimadzu1800 (Japan) with 1 cm matched quartz cells is used for the absorbance measurements.

2. Radwage AS220/C/1 electronic balance is used for weighing the samples.

3. Thermostatic water bath shaker, LabTech, LSB-045S (Korea).

4. Centrifuge, 6000 rpm, Hettich EBA20 (Germany)

5. pH- meter with combined glass electrode, i-Trans,BP3001.

6. FTIR spectrophotometer, WQF-520, China.

7. SEM, Philips XL30, Germany.

8. AFM, SPM AA 3000, USA.

9. XRD, Shimadzu 6000, Japan

The Adsorbent

1. Natural Bauxite

Bauxite clay is obtained from general company for Geological Survey and Mining, Ministry of Industry and Minerals Baghdad, Iraq. It is washed with excessive amounts of distilled water to remove dust and soluble materials. The washed clay is then dried at 120 °C for 1.5 hours and kept in an airtight container. The clay is sieved to the required particles sizes (75, 150, 250 and 300)μm. The particle size of 75 μm was used for the surface in all experiments of this work. The analytical data of bauxite clay are given on Table (1) according to the Company for Geological survey and Mining.

Table (1): The Chemical Specification of Bauxite Clay

Compounds	Al_2O_3	SiO_2	Fe_2O_3
Wt%	50 Min	40 Max	1.3 Max

1. Modified Bauxite

Modified bauxite is prepared by mixing 20g of bauxite and 5g of urea, the mixture is ground using mortar and pestle for half an hour with the addition of a few drops of water, then left for 10 days in an airtight container in order to complete the deployment process for pores. After 10 days, 6.25g of formalin is added to the previous mixture and re-ground again with the addition of 3 drops of concentrated hydrochloric acid until homogeneity. The mixture is then placed in a water bath at (90-100) °C until hardening of the material occurs[11]. The clay is dried and sieved to the required particle size. Natural and modified bauxite is characterized by using FTIR, SEM, AFM, and XRD techniques as illustrated in Figure (12), (13), (14) and (15).

The Adsorbate

Congo red is an azo dye [1- Naphthalene sulfonic acid, 3,3'- [(1, 1' -biphenyl)-

4,4'-diylbis (2,1-diazenediyl)] bis [4-amino -sodium salt (1:2)]] with a molecular formula ($C_{32}H_{22}N_6Na_2O_6S_2$) and molecular weight (6 96. 66 g / mol). It is a brownish-red powder soluble in water and ethanol. The dye is stable in the pH range (3.0-5.0) and show a maximum absorbance at wavelength λ_{max} (498nm)[12,13]. The chemical structure of congo red dye is shown in Figure (1).

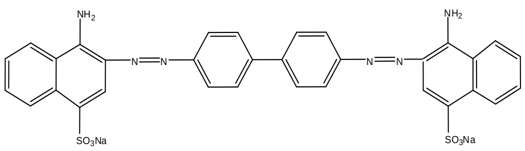


Fig. (1): The Chemical Structure of Congo Red Dye

Congo Red Stock Solution (100 mg/L)

The stock solution is prepared by dissolving an accurately weighed 0.1000g of the dye in distilled water and completing the volume up to the mark in 1L volumetric flask. The stock solution is protected from light and stored at 25°C. The experimental solutions of different concentrations are obtained by serial dilution of the stock solution.

Batch Mode Adsorption Studies

Batch experiments are carried out to determine the effects of contact time, adsorbent weight, pH, ionic strength and particle size of adsorbent. Absorbance values of the solutions of concentrations range (5- 60) mg/L are measured at a selected **λmax** (498 nm) and plotted against the concentration of the dye, Figure (2) shows the spectrum and the calibration curve of congo red.

Percentage of dye removal (R%) and quantity of congo red adsorbed at equilibrium time (Q_e) is calculated by using Eq.1 and 2 respectively [14, 15].

$$R\% = \frac{C_o - C_e}{C_o} \times 100 \quad \text{..........(1)}$$

$$Q_e = \frac{x}{m} = \frac{V(C_o - C_e)}{m} \quad \text{..........(2)}$$

Where:

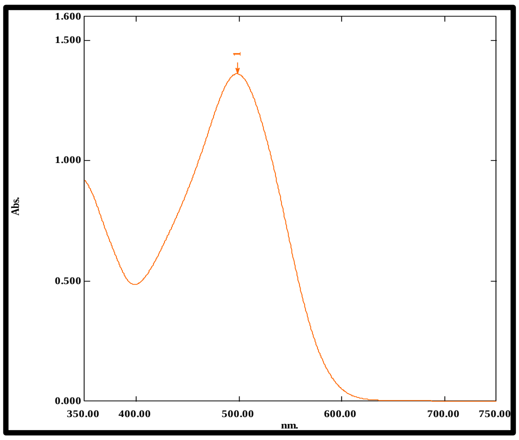
X: the quantity adsorbed (mg).

m: weight of adsorbent (g).

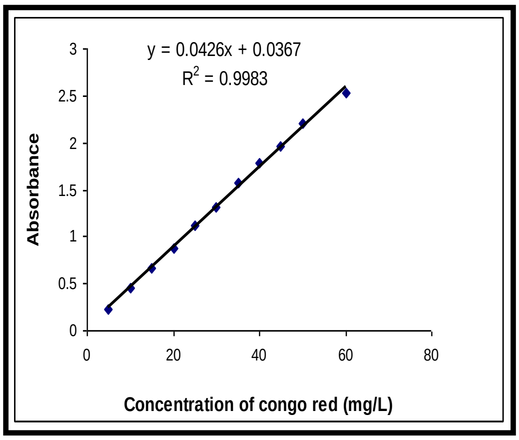
C_o: initial concentration (mg/L).

C_e: equilibrium concentration (mg/L).

V: volume of solution (L).



(a)



(b)

Fig. (2): (a) Absorption Spectrum of 30 mg/L Congo Red (b) Calibration Curve of Congo Red (5-60 mg/L)

Factors Affecting Adsorption Process

Contact Time

In two series of conical flasks 10 ml of 60 mg/L of congo red solution (pH=7.9) is shaken with 0.3 g of natural and modified bauxite at 37.5 °C. The solutions are withdrawn from the shaker for regular time intervals of (5, 10, 20, 30, 45, 60, 90, 120 and 150)min, centrifuged at 3000 rpm for 20 minutes to separate the adsorbent, and the concentration of adsorbate solutions is analyzed spectrophotometrically.

Adsorbent Weight

In a series of conical flasks various weights of the adsorbent (0.1, 0.2, 0.3, 0.4, 0.5 and 0.6) g are mixed with 10 ml of 60 mg/L of congo red solution (pH=7.9). The mixture is shaken at a specified temperature 37.5 °C, then centrifuged at (3000) rpm for (20) minutes to separate the adsorbent. The adsorption capacities for different doses are determined at optimum time and keeping all other factors constant.

Effect of pH

Adsorption experiments are carried out at different pH values (1.5, 3.1, 5.4, 7.3, 9.4 and 11.3). The pH of a series of 10mL of 60mg/L of congo red solutions contained in conical flasks is adjusted by adding the required amounts of 0.1 M HCl and NaOH and were shaken with 0.3g of natural and modified bauxite at 37.5 °C. The experiment is continued as mentioned above and all the other parameters were kept constant while carrying out the experiment.

Effect of Ionic Strength

The effect of the addition (0.1, 0.2, 0.3, 0.4 and 0.5) M of NaCl to a series of 10mL of (60 mg/L) congo red solutions (pH=7.9) equilibrated with 0.3g of natural and modified bauxite is investigated under the same experimental conditions described before.

Particle Size Effect

The effect of particle size (surface area) on adsorption is studied by using four different sizes of sieves (75, 150, 250 and 300) µm. These experiments are performed by using a series of 10mL of 60 mg/L adsorbate solution (pH=7.9) with different particle sizes of the same weight of adsorbents 0.3 g under the same experimental conditions described above.

Effect of Temperature

The adsorption procedure is repeated in the same manner at different temperatures (10.0, 25.0 and 37.5 and 50.0) °C to estimate the basic thermodynamic functions.

Results and Discussion:

Equilibrium Contact Time

The effect of contact time on the amount of congo red adsorbed per unit of adsorbent is investigated at 37.5 °C and constant pH at a fixed concentration. Table (2) and Figure (3) show the variation of Qe and Ce of 60 mg/L congo red solution at 37.5 °C.

A gradual increase was observed in adsorption with increasing contact time up to (90 minutes), after which a maximum value of adsorption is attained. Therefore, the time of 90 minutes is considered as the optimum contact time for both natural and modified bauxite.

Table (2): The Variation of Values of Qe and Ce with Time in the Adsorption Process

Time (min)	Bauxite		Modified bauxite	
	Ce (mg/L)	Qe (mg/g)	Ce (mg/L)	Qe (mg/g)
5	20.0305	1.3323	20.5000	1.3167
20	18.3873	1.3871	19.8427	1.3386
30	17.2606	1.4246	19.6080	1.3464
60	16.1103	1.4630	17.2606	1.4246
90	11.9085	1.6031	12.7300	1.5757
120	11.9085	1.6031	12.7300	1.5757
150	11.9085	1.6031	12.7300	1.5757

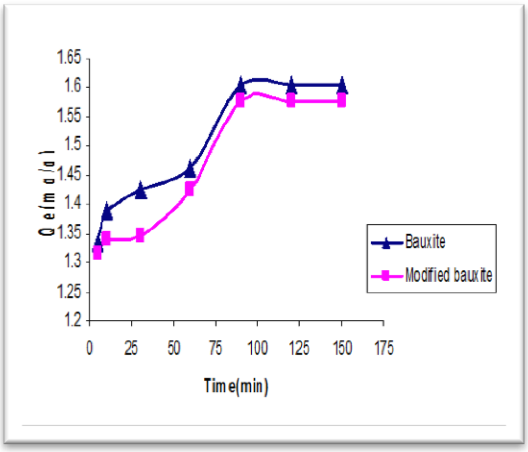


Fig. (3): Effect of Contact Time on the Adsorption of Congo Red by the Adsorbents

Adsorbent Weight

The effect of adsorbent weight on the R% of congo red adsorbed Is studied with 10ml of 60 mg/L initial concentration of congo red. The results are shown on Table (3) and Figure (4). It is obvious that R% of congo red increases with increasing the adsorbent weight of natural and modified bauxite. This may be due to the increase in availability of surface active sites resulting from increased dose[16].

Table(3): The Values of R% and Quantity of Adsorbents for the Congo Red (60 mg/L)

Weight of adsorbent (g)	Bauxite		Modified bauxite	
	Ce (mg/L)	R%	Ce (mg/L)	R%
0.1	15.8521	73.5798	16.2512	72.9147
0.2	13.2699	77.8835	13.8333	76.9444
0.3	11.8380	80.2700	12.6831	78.8615
0.4	9.4202	84.2997	10.8286	81.9523
0.5	6.9554	88.4077	8.1056	86.4906
0.6	6.8615	88.5642	7.5892	87.3513

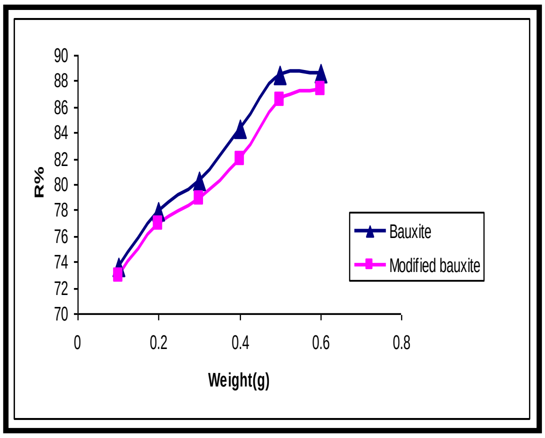


Fig. (4): Effect of Adsorbent Weight on Adsorption of Congo Red by the Adsorbents.

Effect of pH

The effect of pH on the amount of congo red adsorbed is studied by varying the initial pH under constant process parameters at equilibrium conditions.

The extent of adsorption may increase, decrease, or remain unchanged as a result of changing the pH. Many variables can take part in this process such as the nature of chemical state of the adsorbent, adsorbate and solvent [17]. The results in Table (4) indicate that the adsorption capacity in acidic medium increases with increasing and reach a maximum at pH value of 7.3. Beyond this value the increase in pH is accompanied by a decrease in adsorption capacity.

Table (4): The Values of R% and Qe for (60 mg/L) Dye at Different pH

pH	Bauxite		Modified bauxite	
	Ce (mg/L)	R%	Ce (mg/L)	R%
1.5	3.786	93.689	6.932	88.447
3.1	5.594	90.677	8.481	85.865
5.4	6.486	89.190	10.570	82.383
7.9	11.838	80.270	13.786	77.023
9.4	14.444	75.927	26.181	56.365
10.5	18.411	69.315	31.509	47.484

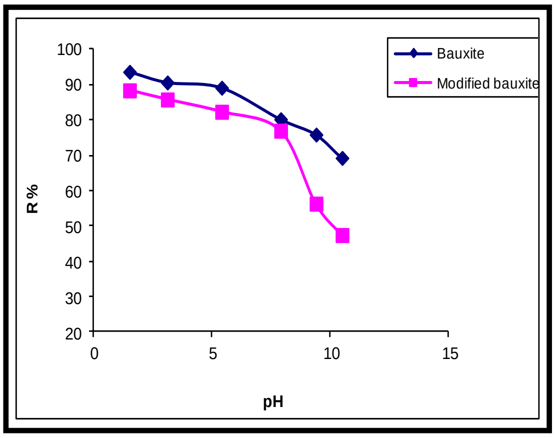


Fig. (5): Effect of pH on Adsorption of Congo Red by the Adsorbents.

Ionic Strength

The effect of ionic strength on adsorption uptake of congo red on natural and modified bauxite has been studied by adding variable concentrations of sodium chloride (0.1, 0.2, 0.3, 0.4 and 0.5) M. In a previous study [18], the following empirical equation explains the relationship between the ionic strength (I) and the amount of adsorption (Qe).

$$Qe = Qe^{\circ} - AI \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Where: Qe°: the amount of adsorption at (I=zero) , A: Empirical constant for the system.

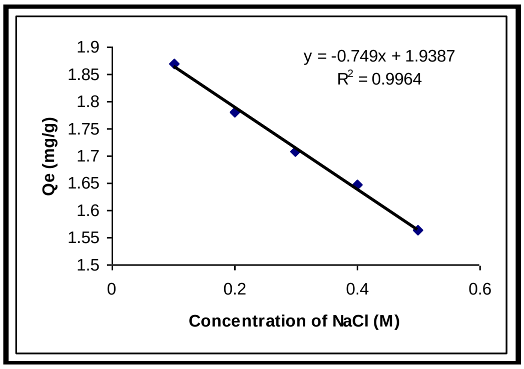
I: Ionic strength.

It is found that the effect of the ionic strength (I) on the adsorption quantity (Qe) at equilibrium is a linear relationship as indicated in Table (5) and Figure (6).

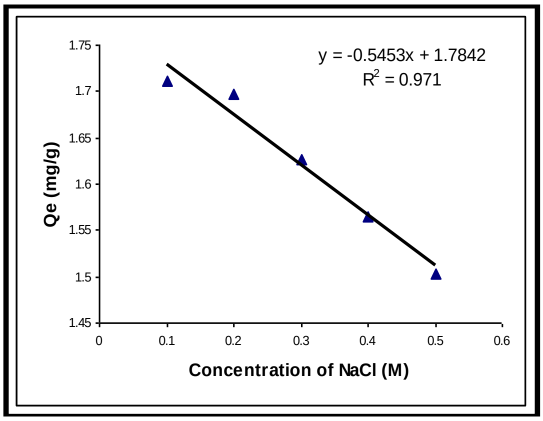
Generally, the increase in the salt concentration results in a decrease of congo red adsorption on natural and modified bauxite and percent removal efficiency. This trend indicates that the adsorption efficiency decreases when NaCl concentration increases in the dye solution, which could be attributed to the competitive effect between dye ions and the salt ions for the sites available for the sorption process [19].

Table (5): The Relationship between the Ionic Strength and Adsorption Quantity of Congo Red (60 mg/L) at 37.5 °C

Conc.of NaCl (M)	Bauxite		Modified bauxite	
	Ce (mg/L)	Qe (mg/g)	Ce (mg/L)	Qe (mg/g)
0.1	3.8803	1.8707	8.6697	1.7110
0.2	6.5798	1.7807	9.1150	1.6962
0.3	8.7394	1.7087	11.2042	1.6265
0.4	10.5939	1.6469	13.0352	1.5655
0.5	13.1056	1.5631	14.8897	1.5037



(a)



(b)

Fig. (6): Effect of Ionic Strength on the Adsorption of Congo Red on (a) Bauxite (b) Modified Bauxite

Particle Size

The effect of particle size on adsorption process is studied by using a fixed concentration (60 mg/L) of congo red solution as an adsorbate and four samples of a same weight of natural and modified bauxite (0.3 g) of different particle sizes (75, 150, 250 and 300 µm). Table (6) and Figure (7) illustrate the influence of particle size of the adsorbents on the amount of congo red adsorbed by natural and modified bauxite at (37.5°C). The results indicate that the maximum quantity of congo red adsorbed on the natural and modified bauxite follows the order: 75 µm > 150 µm > 250 µm > 300 µm. Hence the increase of the surface area (decrease in the particle size) leads to an increase in the adsorption uptake of congo red on both adsorbents, such an increase can be attributed to the increase in the active sites exposed to the adsorbate. Subsequently, the increase in the active sites of the surface will lead to an increase in the adsorption capacity [20, 21].

Table (6): Adsorption Values of Congo Red (60 mg/L) by Natural and Modified Bauxite at Different Size at **37.5 °C**

Particle size (μm)	Bauxite		Modified bauxite	
	Ce (mg/L)	Qe (mg/g)	Ce (mg/L)	Qe (mg/g)
75	11.8850	1.6038	12.6596	1.5780
150	12.3075	1.5898	12.9648	1.5678
250	12.8005	1.5733	13.1995	1.5600
300	13.2230	1.5592	13.4108	1.5530

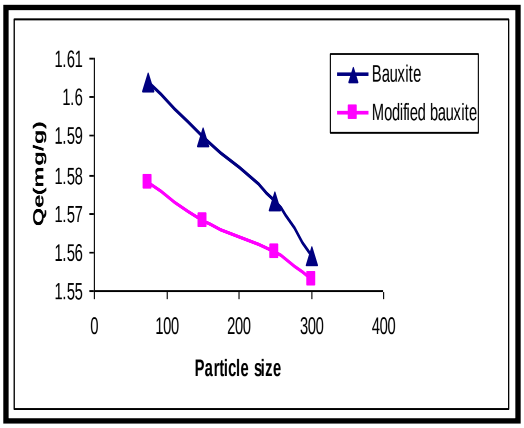


Fig. (7): Effect of Adsorbents Particle Size on the Adsorption

Adsorption Isotherms

Adsorption properties and equilibrium parameters, commonly known as adsorption isotherms, describe how the adsorbate interacts with adsorbents, and give a comprehensive understanding of the nature of interaction. Isotherms help to provide information about the optimum use of adsorbent. Therefore, in order to optimize the design of an adsorption system for the removal of dye from solution, it is necessary to establish the most appropriate correlation for the equilibrium curve. Out of the several isotherm equations available for analyzing experimental sorption equilibrium parameters, the most common isotherm is the Langmuir model. Adsorption of congo red from aqueous solution on natural and modified bauxite is studied at four temperatures (10.0, 25.0, 37.5 and50.0) °C keeping the other parameters of adsorption unchanged. The results of this study represented by the initial concentration of adsorbate (Co), the equilibrium concentration (Ce) and the quantity adsorbed (Qe) are indicated on Table (7) .The quantities adsorbed (Qe) are plotted versus equilibrium concentration (Ce) to obtain the general case of the adsorption isotherms as shown in Figure (8). The results show an increase in adsorptive capacities of natural and modified bauxite as the concentration of the dye increases until reaching a limited value. The general shape of the adsorption isotherm of chlorpyrifos on barley husks consistent with (H_3-type) on the Giles classification which indicates a high affinity between the adsorbate and adsorbent even in very dilute solution [22]. The experimental adsorption data are applied to the empirical Langmuir isotherm (eq.4) [23] and Freundlich isotherm (eq.5) [24] equations.

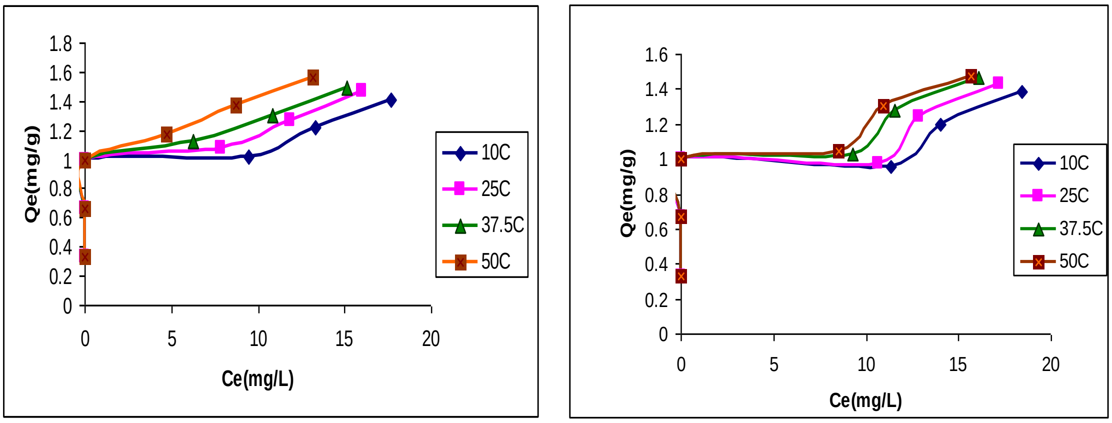
$$\frac{C_e}{Qe} = \frac{1}{a.b} + (\frac{1}{a}).C_e \quad \ldots\ldots\ldots\ldots\ldots(4)$$

$$\log Q_e = \log K_f + \frac{1}{n}\log C_e \quad \ldots\ldots\ (5)$$

These results indicate the applicability of Langmuir and Freundlich isotherms according to the values of linearity (R^2) as shown by the linear relationship of (Ce/Qe) versus (Ce) and (log Qe) versus (log Ce) at different temperatures in Figures (9), (10). The Langmuir and Freundlich constant empirical values are obtained from the linear equation at different temperatures. The values are summarized on Tables (8), (9). The results show that the maximum adsorption capacity (a) of congo red on natural and modified bauxite increases with an increase in temperatures, showing that (a) enhanced at higher temperature.

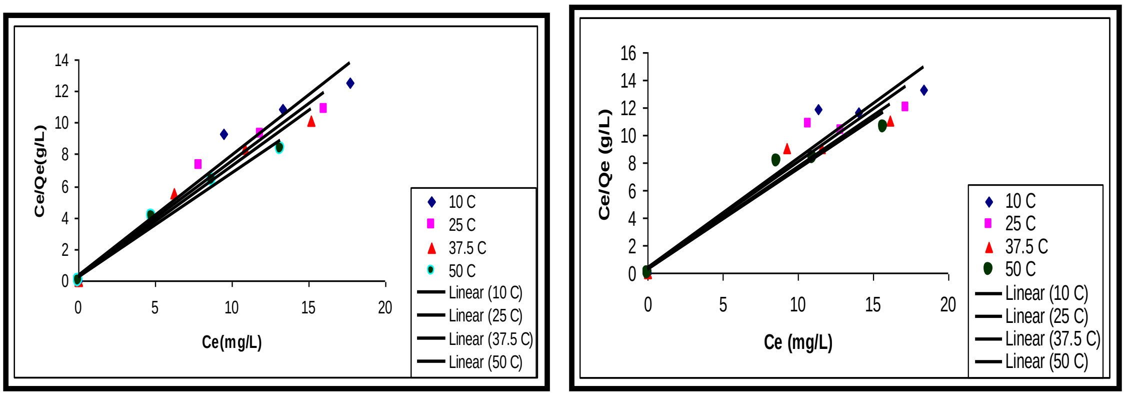
Table (7): Data of Congo Red uptake by Natural and Modified Bauxite at Different Temperatures

Clay	C_o (mg/L)	10.0 °C		25.0 °C		37.5 °C		50.0 °C	
		C_e (mg/L)	Q_e (mg/g)	C_e (mg/L)	Q_e (mg/g)	C_e (mg/L)	Q_e (mg/g)	C_e (mg/L)	Q_e (mg/g)
Bauxite	10	0.000	0.3333	0.000	0.3333	0.000	0.3333	0.000	0.3333
	20	0.000	0.6667	0.000	0.6667	0.000	0.6667	0.000	0.6667
	30	0.000	1.0000	0.000	1.0000	0.000	1.0000	0.000	1.0000
	40	9.4906	1.0170	7.8239	1.0725	6.2277	1.1257	4.7488	1.1750
	50	13.2934	1.2236	11.8380	1.2721	10.8521	1.3049	8.7160	1.3761
	60	17.6831	1.4106	15.9930	1.4669	15.1244	1.4959	13.1291	1.5624
Modified bauxite	10	0.000	0.3333	0.000	0.3333	0.000	0.3333	0.000	0.3333
	20	0.000	0.6667	0.000	0.6667	0.000	0.6667	0.000	0.6667
	30	0.000	1.0000	0.000	1.0000	0.000	1.0000	0.000	1.0000
	40	11.3685	0.9544	10.6408	0.9786	9.2559	1.0248	8.5516	1.0483
	50	14.0211	1.1993	12.8239	1.2392	11.5563	1.2815	10.9460	1.3018
	60	18.3873	1.3871	17.1667	1.4278	16.1103	1.4630	15.6643	1.4779



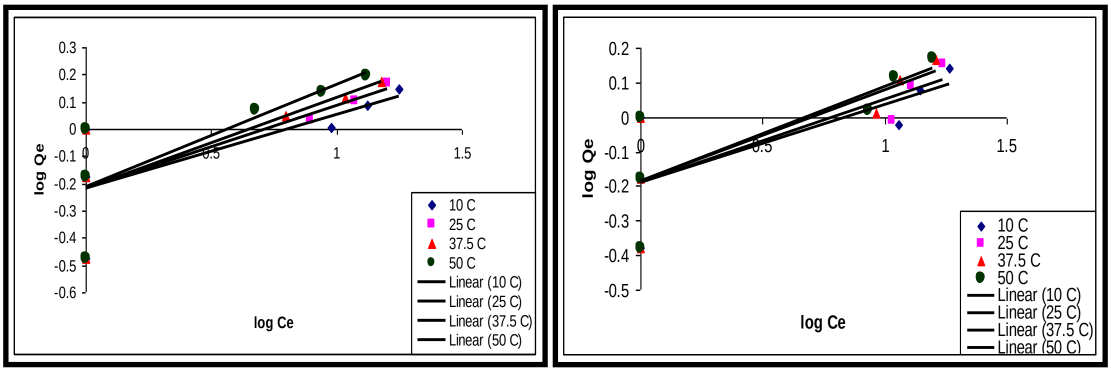
(a) (b)

Fig. (8): Adsorption Isotherm of Congo Red on (a) Bauxite (b) Modified Bauxite at Different Temperatures



(a) (b)

Fig .(9): Linear form of Langmuir Isotherm of Congo Red on (a) Bauxite (b) Modified Bauxite at Different Temperatures



(a) **(b)**

Fig. (10): Linear form of Freundlich Isotherm of Congo Red on (a) Bauxite (b) Modified Bauxite at Different Temperatures

Table(8): The Langmuir Constants Empirical Values and the Correlation Coefficients for the Adsorption of Dye on the Natural and Modified Bauxite at Different Temperatures

Clay	Temperature (°C)	a (mg/g)	b (L/g)	R^2
Bauxite	10.0	1.3106	2.4679	0.9715
	25.0	1.3765	2.7218	0.9760
	37.5	1.4255	3.0731	0.9832
	50.0	1.5076	3.4916	0.9857
Modified bauxite	10.0	1.2568	2.3596	0.9574
	25.0	1.2942	2.5094	0.9559
	37.5	1.3497	2.6069	0.9630
	50.0	1.3772	2.6638	0.9671

Table (9): The Freundlich Constants Empirical Values and the Correlation Coefficients for the Adsorption of Dye on the natural and modified bauxite at Different Temperatures

Clay	Temperature (°C)	n	K_f	R^2
Bauxite	10.0	3.6630	0.6019	0.5444
	25.0	3.2798	0.6028	0.5773
	37.5	3.0312	0.6062	0.5968
	50.0	2.6448	0.6107	0.6207
Modified bauxite	10.0	4.4763	0.6488	0.5635
	25.0	4.1494	0.6489	0.5869
	37.5	3.7793	0.6491	0.6208
	50.0	3.6140	0.6494	0.6362

Thermodynamics of Adsorption Process

The thermodynamic studies play an important role in understanding the nature of adsorption. The thermodynamic parameters are related to the adsorption of dye, such as, Gibbs free energy change ΔG° , enthalpy change ΔH° and entropy change ΔS° .

The change in free energy (ΔG) could be determined from the following equations [25].

$\Delta G = -RT \ln K_{ads}$ ………. (6)

$\ln K_{ads} = (-\Delta H / RT) + (\Delta S / R)$…. (7)

$\Delta G = \Delta H - T \Delta S$ ……………. (8)

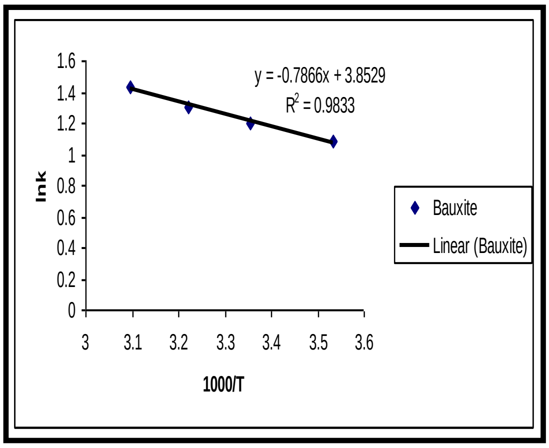
Where R is the gas constant (8.314 J/mol.deg), K_{ads} is adsorption equilibrium constant which is calculated at each temperature (T) from the following equation [26].

$$K_{ads} = \frac{Q_e.0.3(g)}{C_e.0.01(L)} \quad \text{……… (9)}$$

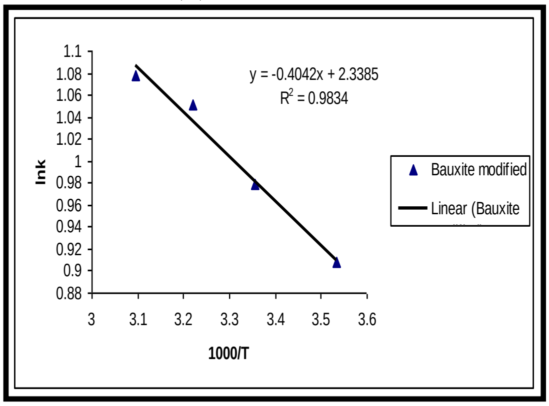
Where Qe is the amount adsorbed (mg/g), Ce is the equilibrium concentration of the adsorbate expressed in mg/L. The values of ΔH and ΔS are determined from the slope and intercept of the linear plot of ($\ln K_{ads}$) vs. (1000/T). The results obtained are given on Table (10) and Figure (11). ΔG,ΔH and ΔS values are listed on Table (12). The positive values of ΔH indicate that the process of adsorption is endothermic in nature. The positive values of ΔS suggest the increasing randomness. The negative ΔG values indicate the spontaneous nature of the adsorption model [27]

Table (10): Effect of the Temperature on the Thermodynamic Equilibrium Constant for the Adsorption of Congo Red on the Natural and Modified Bauxite

Clay	Tem. (°C)	Temp. (K)	1000/T (K^{-1})	Ce (mg/L)	Qe (mg/g)	ln *K*
Bauxite	10.0	283.0	3.5335	10	0.99	1.0886
	25.0	298.0	3.3557		1.10	1.1939
	37.5	310.5	3.2206		1.23	1.3056
	50.0	323.0	3.0960		1.40	1.4351
Modified bauxite	10.0	283.0	3.5335	15	1.24	0.9083
	25.0	298.0	3.3557		1.33	0.9783
	37.5	310.5	3.2206		1.43	1.0508
	50.0	323.0	3.0960		1.47	1.0784



(a)

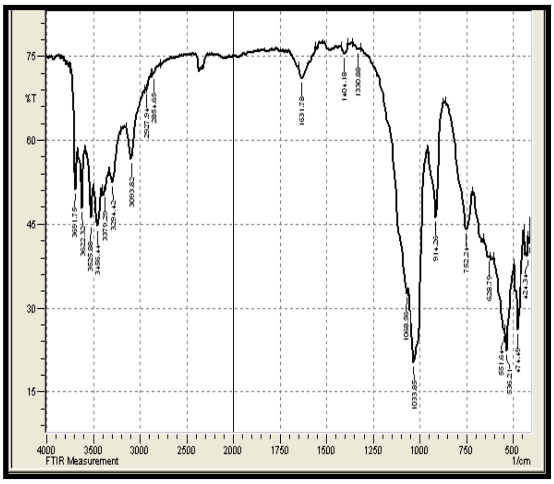


(b)

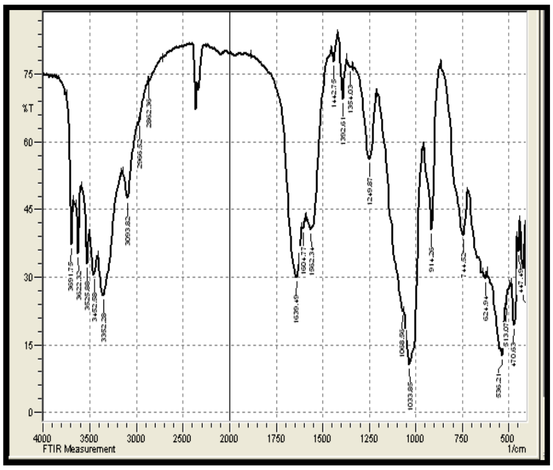
Fig. (11): Plot of ln*k* against Reciprocal Absolute Temperature for Adsorption of Congo Red on (a) Bauxite (b) Modified Bauxite

Table (11): Values of Thermodynamic Functions for the Adsorption of Congo Red on the Natural and Modified Bauxite at Different Temperatures

Clay	Temperature (K)	ΔG(Kj/mol)	ΔH(Kj/mol)	ΔS(J/mol.k)
Bauxite	283.0	-2.5612	+0.0065	9.0731
	298.0	-2.9580		9.9480
	310.5	-3.3705		10.8760
	323.0	-3.8538		11.9514
Modified bauxite	283.0	-2.1370	+0.0034	7.5633
	298.0	-2.4239		8.1453
	310.5	-2.7127		8.7475
	323.0	-2.8960		8.9765

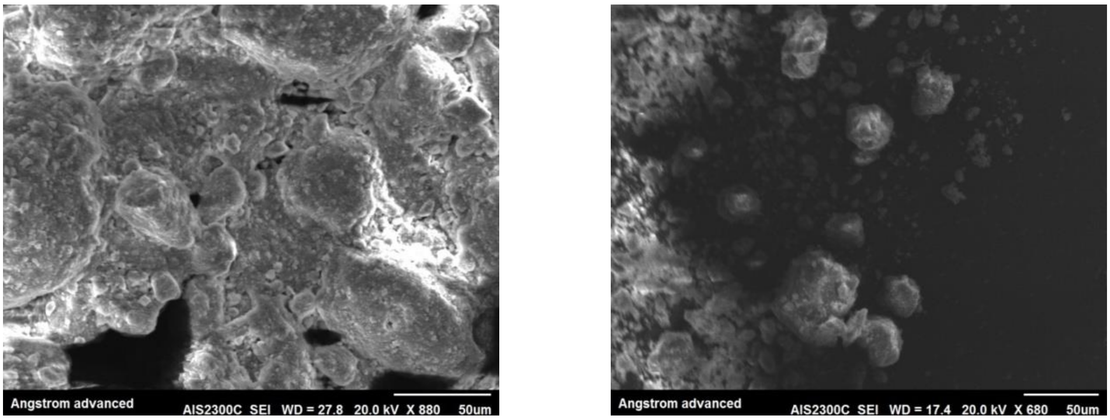


(a)



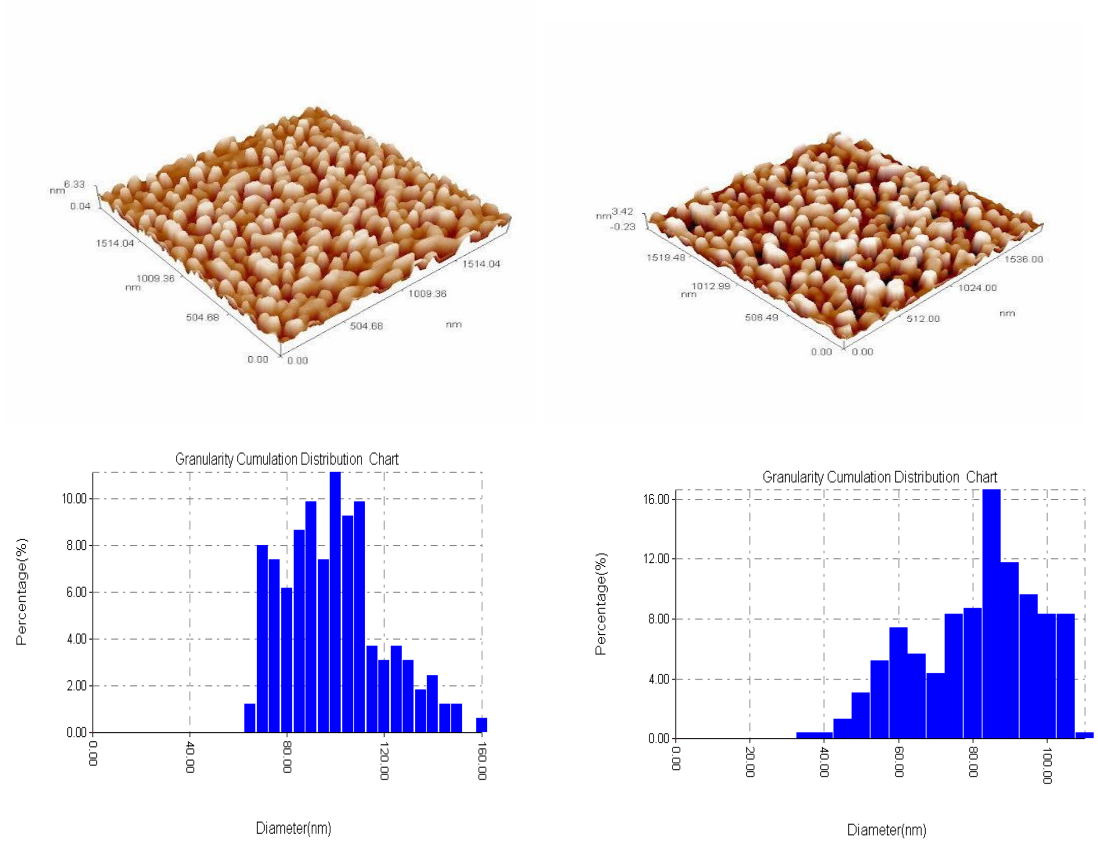
(b)

Fig. (12): FTIR Spectra of (a) Bauxite (b) Modified Bauxite



(a) (b)

Fig. (13): SEM Surface Morphology of (a) Bauxite (b) Modified Bauxite



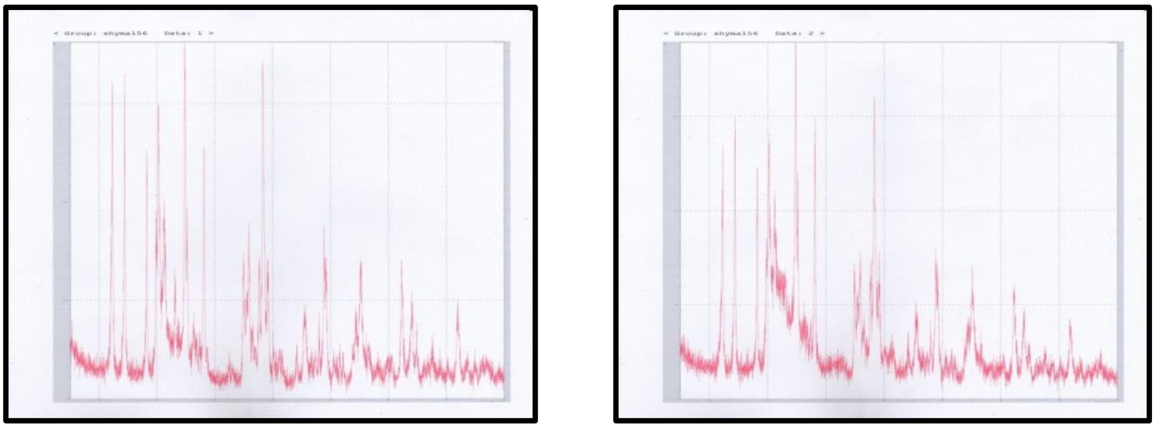
Diameter(nm) <	Volume(%)	Cumulation(%)	Diameter(nm) <	Volume(%)	Cumulation(%)	Diameter(nm) <	Volume(%)	Cumulation(%)
65.00	1.23	1.23	100.00	11.11	59.88	135.00	1.85	94.44
70.00	8.02	9.26	105.00	9.26	69.14	140.00	2.47	96.91
75.00	7.41	16.67	110.00	9.88	79.01	145.00	1.23	98.15
80.00	6.17	22.84	115.00	3.70	82.72	150.00	1.23	99.38
85.00	8.64	31.48	120.00	3.09	85.80	160.00	0.62	100.00
90.00	9.88	41.36	125.00	3.70	89.51			
95.00	7.41	48.77	130.00	3.09	92.59			

(a)

Diameter(nm) <	Volume(%)	Cumulation(%)	Diameter(nm) <	Volume(%)	Cumulation(%)	Diameter(nm) <	Volume(%)	Cumulation(%)
35.00	0.44	0.44	65.00	5.68	23.58	95.00	9.61	82.97
40.00	0.44	0.87	70.00	4.37	27.95	100.00	8.30	91.27
45.00	1.31	2.18	75.00	8.30	36.24	105.00	8.30	99.56
50.00	3.06	5.24	80.00	8.73	44.98	110.00	0.44	100.00
55.00	5.24	10.48	85.00	16.59	61.57			
60.00	7.42	17.90	90.00	11.79	73.36			

(b)

Fig. (14): Granularity Cumulating Distribution and Average Diameter of (a) Bauxite (b) Modified Bauxite



(a) (b)

Fig. (15): X-Ray Diffraction of (a) Bauxite (b) Modified Bauxite

Conclusions:

Main conclusions from this work are:

- Bauxite and modified bauxite have been found to be economically viable and potential adsorbents for removal of congo red dye from aqueous solution.
- The Langmuir and Freundlich isotherms fit the experimental data well for the adsorbate studied. The adsorption capacities of congo red on the adsorbents follow the sequence:
  Bauxite > Modified bauxite.
- The percentage adsorption of congo red on bauxite and modified bauxite increase with the increase in adsorbent dosage.
- The quantity of congo red adsorbed (Qe) on bauxite and modified bauxite surfaces decrease with the increase in particle size of adsorbent surfaces and ionic strength of solution.
- The percentage removal of congo red on bauxite and modified bauxite was dependent on pH solution.
- The thermodynamic values of adsorption process are calculated, the negative values of ΔG indicating a spontaneous process. Posative values of ΔH and ΔS indicates an endothermic process and an increase of disorder.

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إمتزاز صبغة الكونغو الحمراء من محاليلها المائية بواسطة أطيان البوكسايت والبوكسايت المعالج

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الخلاصة:

تم دراسة امتزاز صبغة الكونغو الحمراء من محاليلها المائية على اطيان البوكسايت والبوكسايت المعالج. شخصت السطوح قبل وبعد المعالجة باستخدام مطيافية الاشعة تحت الحمراء و المجهر الالكتروني الماسح ومجهر القوة الذرية ومطيافية الأشعة السينية. درست العوامل المؤثرة في عملية الامتزاز والمتضمنة زمن الاتزان ووزن المادة المازة والدالة الحامضية والشدة الايونية وحجم الدقائق للمادة المازة وتأثير درجة الحرارة في عملية الامتزاز. تم قياس قيم الامتصاص للمحلول قبل وبعد الامتزاز باستخدام مطيافية الاشعة المرئية- فوق البنفسجية. تخضع ايزوثيرمات الامتزاز الى معادلة لانكماير بمعامل خطية يساوي 0.9832 و 0.9630 للبوكسايت والبوكسايت المعالج على التوالي في درجة حرارة 37.5 °C وان الشكل العام لايزوثيرم الكونغو الحمراء يتوافق مع الصنف (H) حسب تصنيف Giles. تم حساب الدوال الثرموديناميكية الاساسية لعملية الامتزاز والمتضمنة طاقة جيبس الحرة والانثالبي والانتروبي واظهرت النتائج ان عملية امتزاز صبغة الكونغو الحمراء على سطح البوكسايت والبوكسايت المعالج هي من النوع الماص للحرارة.

الكلمات المفتاحية: الامتزاز، صبغة الكونغوالحمراء، انموذج لانكماير، نموذج فريندلش، الدوال الثرموديناميكية، البوكسايت، البوكسايت المعالج.