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A Statistical Study Comparing Experimental and Theoretical Yields of Activated Carbon Prepared from Pomegranate (*Punica granatum*) Peels via Chemical Treatment

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Abstract: Due to the great importance that activated carbon has gained through its use in combating pollution, removing dyes components, and other uses, it has been prepared in different ways. In this research, a statistical study was conducted to compare the practical and theoretical values of activated carbon yield prepared from pomegranate peels with some additives (Novolak resin and Beji asphalt) in order to improve its specifications. Since the preparation of activated carbon is controlled by a group of variables, a number of matters were tested for the possibility of finding a linear relationship based on the effect of the amount of the iodine number, density, ash content, and humidity on the yield of all prepared types of activated carbon, and considering the possibility of achieving the relationship through additional additives that can be obtained through it on carbon with a homogeneous surface and specifications. Also, finding a general mathematical relationship that brings together all the types prepared from pomegranate peels after adding new variables representing the percentages of adding asphalt to them and novolak resin used in preparation and activation. This equation makes it possible to control the proportions of the resulting yield before trying to measure, test and evaluate any of the practically calculated values such as the iodine number, density, ash content and humidity using the mathematical equation and calculating them for unknown values if the other characteristics are known. This achieves a shortening of the time period. The success of this method is evidenced by the high experimental R2 values, the low SE, and the logical variation of the variable coefficients.

Keywords: Activated carbon, Pomegranate peels, Yield, Statistical study.

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1. INTRODUCTION

Activated carbon is known as a porous solid material that has a large internal surface area and a developed porous structure. Possessing these characteristics of activated carbon makes it a material with a high adsorption capacity for many chemicals both gaseous and liquid (1). The ability of activated carbon to remove colored substances from aqueous solutions has been known since the fifteenth century when it was used in the sugar industry in britain to shorten the colors. It was then used on a large scale in the manufacture of masks to protect against toxic gases during first world war and its areas of use expanded to include various industrial and chemical processes (2). Activated carbon was prepared at the beginning of the twentieth century from coconut shells but the increased demand for it and the limited quantities available of these shells prompted manufacturers to try to manufacture it from other organic materials. They used coal, coal tar, different types of wood, polymers, and asphalt materials in addition to other materials various others (3).

Activated carbon is characterized by unique properties and cheap prices, which is why it has no competitor in the global market compared to zeolite (as an inorganic adsorbent). Also, the pores and surface area are distributed in a very wide and

indefinite manner compared to zeolite and this is what made carbon one of the most important adsorbent materials even though more than 30% of Carbon research specializes in developing activated carbon in terms of obtaining new sources, modern manufacturing processes, and searching for future applications (4).The global demand for activated carbon is increasing as a result of environmental problems especially in the field of water and air purification. However, the raw materials used to produce activated carbon are not renewable and despite the great influence of natural raw materials on the specifications of the final product the search for cheap adsorbent materials With less impact and toxicity on the environment, it has led to the use of by-products of agricultural products, oil waste, the use of newspapers, old tires, and any remaining carbon materials from industrial processes and various treatments to prepare activated carbon (5).

Activated carbon is a complex product that is difficult to classify based on its behavior, surface area, and method of preparation. However, it has been classified based on its physical properties into: Powdered activated carbon it has a particle size of less than 1.0 mm, an average diameter of 0.15-0.25 mm, and a large internal surface area. This type is used in gravity filters (6). Granulated activated carbon size of particles of this type is relatively larger and the external surface area is smaller when compared to activated carbon in powder form, as the size of its particles ranges between (1.5-2.5 mm). These carbon particles are used to treat water, remove odors, separate components of the flow system, and adsorption of gaseous substances and vapors (6, 7). Extruded activated carbon is made by extruding a quantity of activated carbon in powder form into a cylindrical shape, producing a mass of activated carbon with a diameter ranging between (0.8-130 mm), it is used in gas phase adsorption applications. Polymer coated activated carbon prepared by coating porous activated carbon with polymeric materials to give a smooth, permeable cover and cover that does not allow the pores to become clogged, it used in filtration processes (6). Activated carbon in the form of molecular sieve it has a structure in the form of molecular sieves, and contains a high percentage of small pore sizes compared to other pores. Also is used to separate gases, such as separating nitrogen and oxygen at room temperature (8). Activated carbon fibers prepared by developing the non-crystalline structure of the primary material such as rayon, bitumen, polymers, phenolic resins at a temperature (800°C), followed by a steam activation process at (800-1000) °C, thus obtaining a very high surface area of up to (2500 cm^2/g), activated carbon fibers have a number of advantages over granular activated carbon in that they have porous structures and a large physical surface area (6, 9).

There are many methods and materials used in preparing activated carbon, and some of them are as follows: Al-Ghannam *et al.* (10) were able to prepare activated carbon from *Morus Nigra* using an excess of potassium hydroxide at (25±550)^oC for three hours. Aweed (11) was able to prepare several models of activated carbon using some plant wastes (coconut shells, date pits, sunflower peels, and harvest waste) by reacting them with an excess of potassium hydroxide KOH[1:2] (plant waste: base) at (25±550)°C for three hours. Hamdoon *et al.* (12) were able to prepare activated carbon from coconut shells using different percentages of Baiji asphalt as an additive and using the chemical activation method. The effect of adding different percentages of Baiji asphalt on the properties of the activated carbon prepared from coconut shells was observed. Saleh *et al.* (13) were able to prepare activated carbon from Iraqi reed material by carbonizing it at a temperature of 450 °C. It was found that the prepared carbon was characterized by density (0.451 g/cm^3), ash content (9.4%), moisture content (4.8%), and using X-rays was found to lack a crystal structure with less graphite and silica.

Ramakrishnan *et al.* (14) were able to prepare types of activated carbon from Jatropha husk peels, biodiesel fuel, the seeds of which are used as fuel for cars, industrial and agricultural solid waste by chemically activating them using (H_3PO_4, HNO_3, HCl, H_2SO_4, NaOH, $ZnCl_2$). The physical and chemical properties were studied it was found that the prepared types of activated carbon are low cost and are used to remove organic and inorganic substances from water. Ragan *et al.* (15) were able to prepare activated carbon from the renewable resource cellulose-lignin, which contains 66% carbon by weight, by carbonizing it at a temperature of 950°C for 5 minutes. It was found that the prepared samples possess good adsorptive properties. Zengin *et al.* (16) were able to prepare activated carbon from the pyrolysis of melamine waste (coated chipboard) by carbonizing it at a temperature of (600-800)^oC and then chemically activating it with NaOH. It was found that the prepared activated carbon had a higher surface area at a temperature of 600^oC and a concentration of 50% by weight of sodium hydroxide, it was also found that its outer surfaces have an amorphous and heterogeneous composition.

Al-Badran (17) prepared activated carbon from local raw materials by treating bomber cores with concentrated phosphoric acid in a ratio of [1:1], then heat-treated them at 500°C for one hour. The internal surface area of the activated carbon prepared by the nitrogen escape method (BET) was calculated and was found to be 886.697 m^2/g it was found to have a high adsorption capacity. Abechi *et al.* (18) studied the preparation of activated carbon by chemically activating palm kernel shells with KOH at 800°C for 45 minutes it was found to have a high adsorption capacity. Salman (19) studied the preparation of activated carbon from pomegranate tree branches (BP) through physicochemical activation by treatment with potassium hydroxide and carbon dioxide. The effect of activation temperature, activation time, and percentage of chemical impregnation of carbon with methylene blue dye (MB) and its removal from its aqueous solution was studied. The best activation

temperature was 620°C, activation time was 1.4 hours, and the yield was 16%, the removal percentage for methylene blue dye was 92.5%.

Njewa *et al.* (20) were able to prepare activated carbon from rice peels and potato peels by chemical activation with 40% phosphoric acid H_3PO_4 the effect of the carbonization temperature and impregnation rate was studied using the continuous activation period, also studied physical, chemical properties such as (surface shape, surface charge), and amines aromatics, other functional groups were detected. This is excellent for adsorption through surface chemistry studies. Islam *et al.* (21) prepared activated carbon from jute sticks by chemical activation using H_2SO_4, H_3PO_4, and $ZnCl_2$ the activating factors and carbonization temperatures were studied, which ranged between 300-350°C. The carbon atoms were identified by iodine absorption and the method of infrared spectroscopy (FT-IR).

In this research, a statistical study was conducted to compare the experimental and theoretical values of the yield of activated carbon prepared from (pomegranate peels as a raw material with additions of polymeric residues and petroleum residues). here able to control the percentages of the resulting yield before trying, testing and evaluating any of the experimentally calculated values such as the iodine number, density, content, Ash and humidity. The success of this method is evidenced by the high experimental R^2 values, the low SE, and the logical variation of the variable coefficients.

2. EXPERIMENTAL SECTION

2.1. Preparation of Activated Carbon

The raw material is prepared by taking the peels of pomegranate in their natural dry form then grinding them and turning them into powder. Then comes the primary carbonation stage, where the prepared raw material is placed in a stainless steel bowl coated with a layer of nickel and mixed with potassium hydroxide in proportions ranging between [(1:0.5) - (1:3)] [pomegranate peels: KOH]. An increase of 0.5% by weight of potassium hydroxide for each reaction. The mixture was homogenized by adding (5-10)mL (milliliters) of distilled water and then heated to a temperature of 350°C with continuous stirring for three hours until the release of gases stopped. Then transfer the mixture to final carbonization and activation. Heat the mixture to a temperature (25±550)°C for two hours in order to complete the activation process, the samples were then left to cool to room temperature.

Finally, purification of activated carbon was completed, prepared and contaminated with the base and metal components, the samples were washed with distilled water several times for the purpose of removing unreacted potassium hydroxide and ensuring that the product of the washing process was neutral. Then the resulting carbon was treated with a solution of (10%) hydrochloric acid and using a thermal sublimation process for two hours to remove any trace of ions and to reduce Mineral components to a minimum. Then, it was washed with distilled water several times, and the resulting carbon samples were dried at 110-120°C for 24 hours, sieved using 20-40 mesh sieves, and stored in a dehydrator, isolated from air and moisture.

2.2. Preparing Activated Carbon Samples from Mixtures

Activated carbon was prepared from a mixture of (pomegranate peels with asphalt), where the pomegranate peels were mixed with Baiji asphalt in proportions ranging between (5-25)% by weight of the asphalt material, with an increase of 5% by weight of the asphalt for each sample. Activated carbon was prepared from a mixture of pomegranate peels and novolak resin, where the pomegranate peels were mixed with thermally crushed novolac resin (the novolak resin, represented by the waste of this material used in the manufacture of home cooking utensils, was cut into small pieces and placed in a covered ceramic crucible). With aluminum foil, then heated the lid in an electric oven at 400°C for one hour. After that, the material was taken out and left to cool to room temperature, then it was crushed into a fine powder using a mortar. In proportions ranging from (5-25)% by weight with an increase of 5% by weight of novolak resin for each sample. Activated carbon was prepared from a mixture of (pomegranate peels with asphalt and novolak resin): Pomegranate peels were mixed with a mixture of (asphalt: novolak resin) [1:1] in proportions ranging from (5-25)% by weight with an increase of 5% by weight of the mixture in every addition.

Repeated the processes mentioned in section (2.1) on the mixtures prepared in the above, and using a fixed ratio of potassium hydroxide [1:2.5] [pomegranate peels: KOH] as the best ratio used to prepare activated carbon from pomegranate peels (22, 23).

2.3. Conducting some Measuring on Prepared Activated Carbon Samples

2.3.1. Measuring internal surface area of activated carbon by adsorption iodine

This method is one of the well-known and common methods used to determine the internal surface area of activated carbon, and it represents the number of milligrams of iodine adsorbed from the solution by one gram of activated carbon. One gram of activated carbon was weighed and placed in a 250 mL conical flask. 10 mL of 5% HCl was added to it. The contents of the flask were heated to the boiling point for half a minute and then cooled to laboratory temperature. After that, 100 mL of 0.1 M iodine solution was added to it. The mixture was shaken for half an hour, then filtered, discarding 20 mL at the beginning of the filtration process, and collecting 50 mL to titrate it with a 0.1 M solution of aqueous sodium thiosulfate. Using starch as detector the volume of sodium thiosulfate used was calculated from the buret and then the weight of

iodine adsorbed by the activated carbon was calculated (24).

2.3.2. Measuring of density

A certain amount of activated carbon was placed in a volumetric bottle with a capacity of 5 mL so that the activated carbon occupies its volume, while making sure that the carbon particles were at one level at the mark. After that, the carbon in the volumetric bottle was weighed using a sensitive balance and the density was calculated as follows:(25)

Density (g/cm^3) = mass / volume

2.3.3. Measuring of ash content percentage

Weigh (1 g) of activated carbon and place it in Porcelain Crucible. The Porcelain Crucible is placed in an electric oven at (1000°C) for three hours. Then it was left to cool, then it was weighed using a sensitive balance, then the weight of the remaining ash was calculated for each of the prepared activated carbon models, then the percentage of ash in each sample was calculated (26).

2.3.4. Measuring of humidity percentage

Weigh (1 g) of the sample accurately and place it in an oven at 150°C for three hours, then cool it and weigh it accurately and quickly, and from the difference in weights, the humidity content is calculated in the form of a percentage (27).

2.4. Conducting a Statistical Study

This study was conducted using a statistical program, SPSS where the version number is 19 and the release date is 2010.

3. RESULTS AND DISCUSSION

The statistical study is complementary to practical studies, and through it the effect of a group of independent variables (x) on a dependent variable (y) can be tested through an equation called the multivariate linear regression analysis equation, which can be represented by the following relationship:

$$y = b + a_1x_1 + a_2x_2 + \cdots + a_nx_n \quad (1)$$

Through this equation it is possible to estimate the extent of the influence of a group of independent variables (x_1, x_2,….x_n) on the dependent variable (y) from the magnitude of its coefficients (a_1, a_2,….a_n) respectively. While the value of b is a fixed magnitude for a reference value. The success of the linear relationship is usually evaluated through two criteria: the correlation coefficient R^2 whose values are limited to (0-1), and the relationship is linear whenever the value of R^2 approaches one. The other criterion is the value of the standard deviation SE which represents the amount of deviation of the experimental value from the theoretically calculated value which should at best not exceed 5% of the experimental value. The values of the coefficients of a(x) indicate the amount of slope in the straight line, or in other words, the extent to which the value of x affects y while the sign of a indicates the nature of the relationship whether inverse or direct.

The statistical study will be conducted on the activated carbon prepared from the peels of pomegranate (Pp). Tables 1-4 show the specifications of the prepared activated carbon (22, 23).

Table 1: The properties of the activated carbon prepared from Pp.

S	RM : KOH	ION	Dy	ASC	HYC	Yd
C_n	1:0	339.420	0.397	3.21	9.07	21.705
1	1:0.5	654.959	0.383	3.19	8.13	20.401
2	1:1	674.507	0.306	3.17	10.55	18.810
3	1:1.5	710.808	0.292	3.14	10.76	16.528
4	1:2	780.620	0.273	3.08	10.88	14.904
5	1:2.5	822.507	0.261	3.02	11.87	13.327
6	1:3	788.997	0.281	4.00	7.03	8.800
B.D.H.*	-	908	0.345	3.200	0.80	-

S: samples , RM: Raw material, ION : Iodine Number (mg/g) , Dy: Density (g/cm^3), ASC: Ash Content%, HYC: Humidity Content%, Yd: Yield% , B.D.H.*: Commercial carbon

Table 2: Properties of activated carbon prepared from mixture (Pp with BAs) using [1:2.5] [RM:KOH].

S	BAs	ION	Dy	ASC	HYC	Yd
7	5	830.884	0.256	3.01	11.89	14.105
8	10	864.394	0.218	2.94	11.42	15.232
9	15	881.149	0.178	2.82	12.01	16.034
10	20	900.696	0.118	1.75	12.20	17.691
11	25	925.828	0.080	1.68	12.38	21.631
B.D.H.*	-	908	0.345	3.200	0.80	-

BAs: Beji Asphalt%

Table 3: Properties of activated carbon prepared from mixture (Pp with REN) using [1:2.5] [RM:KOH]

S	REN %	ION	Dy	ASC	HYC	Yd
12	5	836.469	0.221	2.98	11.93	14.831
13	10	892.318	0.210	2.92	11.47	16.243
14	15	945.375	0.196	2.54	12.41	18.284
15	20	976.092	0.106	1.87	12.29	20.072
16	25	1004.017	0.075	1.23	13.71	22.471
B.D.H.*	-	908	0.345	3.200	0.80	-

REN: Resin Novolak

Table 4: Properties of activated carbon prepared from mixture (Pp with the Asphalt and the REN) using [1:2.5] [RM:KOH]

S	Mixed(Asphalt, REN)%	ION	Dy	ASC	HYC	Yd
17	5	864.394	0.220	2.86	11.98	14.907
18	10	981.677	0.186	2.75	11.59	18.071
19	15	995.639	0.144	2.08	12.61	19.231
20	20	1017.979	0.104	1.72	12.74	27.580
21	25	1129.677	0.064	1.79	13.92	34.410
B.D.H.*	-	908	0.345	3.200	0.80	-

In order to complete this study, we conducted the following:

First, the relationship between the different variables whether y or x values was evaluated which represented the basis for this study, which are the values of the yield of the prepared activated carbon, the iodine number, density, ash content, and humidity by applying the simple linear relationship of the straight line which are:

$$y = b + ax \quad (2)$$

The relationship between these variables was evaluated by calculating the R^2 values for each of them with each other. The results obtained were included in Tables 5-8.

Table 5: Results of statistical analysis of data taken from Table 1.

	Yd y	**ION x_1**	**Dy x_2**	**ASC x_3**	**HYC x_4**
Yd (y)	1				
ION (x_1)	0.716	1			
Dy (x_2)	0.506	0.698	1		
ASC (x_3)	0.454	0.039	0.004	1	
HYC (x_4)	0.051	0.052	0.237	0.684	1

Table 6: Results of statistical analysis of data taken from Table 2.

	Yd y	**ION x_1**	**Dy x_2**	**ASC x_3**	**HYC x_4**
Yd (y)	1				
ION (x_1)	0.878	1			
Dy (x_2)	0.893	0.969	1		
ASC (x_3)	0.781	0.776	0.892	1	
HYC (x_4)	0.571	0.473	0.613	0.639	1

Table 7: Results of statistical analysis of data taken from Table 3.

	Yd y	**ION x_1**	**Dy x_2**	**ASC x_3**	**HYC x_4**
Yd (y)	1				
ION (x_1)	0.947	1			
Dy (x_2)	0.904	0.788	1		
ASC (x_3)	0.957	0.827	0.967	1	
HYC (x_4)	0.755	0.580	0.654	0.805	1

Table 8: Results of statistical analysis of data taken from Table 4.

	Yd y	ION x_1	Dy x_2	ASC x_3	HYC x_4
Yd (y)	1				
ION (x_1)	0.837	1			
Dy (x_2)	0.929	0.882	1		
ASC (x_3)	0.716	0.628	0.885	1	
HYC (x_4)	0.815	0.671	0.821	0.680	1

The second step to complete this study included performing a multivariate regression analysis for each of the Tables 1-4 separately which included the preparation of activated carbon with different methods and additives. Three variables were chosen for the purpose of analysis: the iodine number, density, and ash content as the best variables based on the preliminary study in first step due to the lack of degrees of freedom in the statistical analysis due to the small number of observations. The results of the regression analysis obtained are listed in the following Tables 9-12.

Table 9: Results of regression analysis of data taken from Table 1.

Variables	Variables Coefficient	Fixed value	
ION	-0.035		R^2= 0.994
Dy	18.634	b= 56.004	SE= ±0.507
ASC	-6.226		
Observation Number = 6			

Table 10: Results of regression analysis of data taken from Table 2.

Variables	Variables Coefficient	Fixed value	
ION	0.026		R^2= 0.895
Dy	-23.453	b= -1.089	SE= ±1.901
ASC	-0.277		
Observation Number = 5			

Table 11: Results of regression analysis of data taken from Table 3.

Variables	Variables Coefficient	Fixed value	
ION	0.021		R^2= 0.999
Dy	11.265	b= 4.018	SE= ±0.142
ASC	-3.205		
Observation Number = 5			

Table 12: Results of regression analysis of data taken from Table 4.

Variables	Variables Coefficient	Fixed value	
ION	-0.071		R^2= 0.992
Dy	-366.840	b= 106.495	SE= ±1.385
ASC	17.667		
Observation Number = 5			

When the results obtained from the regression analysis were used to calculate the yield theoretically and compare it with the experimental values, the results were as listed in Tables 13 and 14.

Table 13: Comparison between the experimental and calculated results of the activated carbon yield prepared from the data of Tables 1 and 2 respectively.

	Results Table (1)				Results Table (2)		
S	**Exp. val**	**Cal. val**	**diff**	**S**	**Exp. val**	**Cal. val**	**diff**
1	20.401	20.356	0.045	1	14.105	13.676	0.429
2	18.810	18.362	0.448	2	15.232	15.458	-0.226
3	16.528	17.017	-0.489	3	16.034	16.865	-0.831
4	14.904	14.593	0.311	4	17.691	19.077	-1.386
5	13.327	13.277	0.050	5	21.631	20.641	0.990
6	8.800	8.721	0.079				

Exp. val: Experimental value, Cal. val: Calculated value
diff.: difference, S : Sequence

Table 14: Comparison between the experimental and calculated results of the activated carbon yield prepared from the data of Tables 3 and 4 respectively.

	Results Table (3)				Results Table (4)		
S	**Exp. val**	**Cal. Val**	**diff**	**S**	**Exp. val**	**Cal. val**	**diff**
1	14.831	14.523	0.308	1	14.907	14.946	-0.039
2	16.243	15.764	0.479	2	18.071	17.148	0.923
3	18.284	17.938	0.346	3	19.231	19.727	-0.496
4	20.072	19.717	0.355	4	27.580	26.454	1.126
5	22.471	22.005	0.466	5	34.410	34.434	-0.024

Observing the results obtained from the tables above, we note that there is a linear relationship with a good correlation coefficient and a low standard deviation. In addition, there is a correspondence in the practical values and the values calculated from the results obtained from the regression analysis. This result encouraged us to complete this study and try to find one general equation that combines all Methods By introducing new variables including adding humidity content as well as the proportions of additives in the preparation of KOH, asphalt and novolak resin the data used in the regression analysis are listed in Table 15.

Table 15: Data used in regression analysis to find a general equation.

Yd	ION	Dy	ASC	HYC	%KOH	%Asp	%Nov	%Mix
20.401	654.959	0.383	3.190	8.130	0.5	0	0	0
18.810	674.507	0.306	3.170	10.550	1	0	0	0
16.528	710.808	0.292	3.140	10.760	1.5	0	0	0
14.904	780.620	0.273	3.080	10.880	2	0	0	0
8.800	788.997	0.281	4.000	7.030	3	0	0	0
14.105	830.884	0.256	3.010	11.890	2.5	5	0	0
15.232	864.394	0.218	2.940	11.420	2.5	10	0	0
16.034	881.149	0.178	2.820	12.010	2.5	15	0	0
17.691	900.696	0.118	1.750	12.200	2.5	20	0	0
21.631	925.828	0.080	1.680	12.380	2.5	25	0	0
14.831	836.469	0.221	2.980	11.930	2.5	0	5	0
16.243	892.318	0.210	2.920	11.470	2.5	0	10	0
18.284	945.375	0.196	2.540	12.410	2.5	0	15	0
20.072	976.092	0.106	1.870	12.290	2.5	0	20	0
22.471	1004.017	0.075	1.230	13.710	2.5	0	25	0
14.907	864.394	0.220	2.860	11.980	2.5	0	0	5
18.071	981.677	0.186	2.750	11.590	2.5	0	0	10
27.580	1017.979	0.104	1.720	12.740	2.5	0	0	20

Asp : Asphalt , Nov : Novolak

The results of the regression analysis obtained from the data listed in Table 15 were as follows:

Table 16: Results of regression analysis of the data in Table 15.

Variables	variables Coefficient	
ION	-0.014	
Dy	3.016	b= 28.818
ASC	-0.378	R^2= 0.978
HYC	0.318	SE= ±0.830
%KOH	-3.460	
%Asphalt	0.506	
%Novolak	0.881	
Observation Number = 18		

The results listed in Table 16 can be formulated in the form of a mathematical equation and written as follows:

$$yield = 28.818 - 0.014 \times Iod. + 3.016 \times Density \quad (3)$$

When using above equation to theoretically calculate the yield ratio values and compare them with the experimental values it was found that there is a large correspondence between the calculated values and the experimental values with an error rate not exceeding 5% as shown in Table 17.

Table 17: Comparison between the experimental and theoretical results of the prepared activated carbon yield From the data in Table 14.

Seq	$y_{exp.}$	$y_{calc.}$	$y_{exp.} - y_{calc.}$
1	20.401	20.453	-0.052
2	18.810	18.994	-0.184
3	16.528	16.792	-0.264
4	14.904	14.088	0.816
5	8.800	8.963	-0.163
6	14.105	13.881	0.224
7	15.232	15.104	0.128
8	16.034	16.912	-0.878
9	17.691	18.852	-1.161
10	21.631	20.399	1.232
11	14.831	14.321	0.510
12	16.243	15.913	0.330
13	18.284	18.100	0.184
14	20.072	20.144	-0.072
15	22.471	22.883	-0.412
16	14.907	15.864	-0.957
17	18.071	18.442	-0.371
18	27.580	27.251	0.329

4. CONCLUSIONS

From the results of this study, it was concluded that the yield of prepared activated carbon can be calculated by knowing the percentage of ash, humidity, density, and iodine number. Any of these variables can also be calculated with an unknown substance if the value of the other variables is available. The values of the parameters of the variables indicate that the yield percentage is directly proportional to the density and to the humidity content, and this is logical, as increasing the density increases the yield percentage of the activated carbon, and increasing the yield of the prepared activated carbon increases the amount of humidity adsorbed on its surface. Increasing the base percentage reduces the yield because the user burns it to prepare in the catalysis process and increases the ash content percentage. Increasing asphalt or novolak resin increases the yield of the prepared carbon because increasing these materials increases the carbon content of the materials used in preparing the activated carbon. There is a large correspondence between the percentage of calculated and experimental results with a percentage that does not exceed the percentage of experimental error which is inferred from the percentage of standard deviation.

5. CONFLICT OF INTEREST

The author have no conflicts of interest.

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