



Trade Science Inc.

August 2007

Volume 2 Issue 2

CHEMICAL TECHNOLOGY

An Indian Journal

Full Paper

CTAIJ, 2(2), 2007 [43-49]

Studying The Effect Of Structural Modification On The Production Of Activated Carbon From Heavy Crude Oil Residues By Chemical Treatment

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Received: 3rd February, 2007; Accepted: 8th February, 2007

ABSTRACT

Our study involves the use of residual petroleum product such as that of Qaiyarah heavy crude oil in Northern Iraq, which contains a large amount of sulphur (7.78%) and other heteroatoms. The study involves increasing the asphalt and asphaltene contents by employing direct oxidation with and/or by using a certain type of catalysts (FeCl_3 , ZnCl_2 and CoCl_2). The study involves variation of the reaction parameters such as temperature (250-350°C), time (1-3) hr. and catalyst amount (1-3%). The results indicate production of some carbon of a good quality, after the activated carbon was prepared, its characteristics from the physical and chemical point of view were studied and compared with the authentic carbon aiming to evaluate the carbon produced. The best samples obtained were compared with the authentic carbon when the ratio of feed/base, (1:2) at time (2-3) hr., temperature (350)°C and catalyst (2%) of FeCl_3 . Activation of the carbon (after oxidation at 350°C and primary carbonization at 350°C) was carried out at about $550 \pm 25^\circ\text{C}$. Catalysts used in the research (ZnCl_2 and CoCl_2) gave a good result but not as the same as that of FeCl_3 . Testing the activity of the prepared carbon through I_2 number, methylene blue and carboxylic acid adsorption in aqueous solutions gave very encouraging results comparable to those obtained from a good quality commercial grade activated carbons. Other relevant properties such as mechanical resistance, bulk density, humidity and ash content were also assessed.

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KEYWORDS

Heavy residue;
Oxidation;
Catalyst;
Chemical treatment;
Activated carbon;
Adsorption properties.

INTRODUCTION

Activated carbons were produced from different origins^[1-5], such as the carbonizing residual of petroleum with elemental sulphur^[6], raw elemental sul-

phur from Mishraq deposit (containing 1% Bituminous impurity) and the "foam" and "cake industries". Wastes obtained from sulphur purification process operating at the Mishraq Field in Northern Iraq contain about 80% elemental sulphur^[7]. Also activated

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carbon can be prepared from petroleum residual materials by their carbonization with H_2SO_4 ^[8].

We also reported preparation activated carbon from petroleum residual materials by their carbonization and activation with NaOH^[9].

In this study the heavy crude oil pretreatment is to modify the composition of petroleum residue incomplete. The study involves increasing the asphaltene content by employing catalytic oxidation. The asphaltene consists of condensed polynuclear aromatic ring systems in more massive systems, the number of rings reach as twenty^[10]. The concept of asphaltene being a sulphur polymer or even a regular hydrocarbon polymer, meshlike networks as graphite.

The structure of activated carbon is like that of the graphite^[11] to some extent and so is asphaltene. The modified raw material (high asphaltene content) after carbonized was treated chemically by the use of KOH to produce active carbon with good quality.

EXPERIMENTAL

Materials and equipments

All materials used were of high purity supplied by well known companies. The material include

KOH, $CdSO_4$, $FeCl_3$, $CoCl_2$, $ZnCl_2$, I_2 , $Na_2S_2O_3$, HCl, $BaCl_2$, Na_2O_2 , starch, CCl_4 , petroleum ether, glycerol, CH_3COOH , $H_2C_2O_4$, malonic acid and succinic acid: from BDH and Fluka, H_2SO_4 from Mishraq Sulphur Deposit in Northern Iraq. Methylene blue pigment: Hopkin and Williams.

Equipment

The following types of equipment were used

Electrical furnace Thermoline Muffle furnace, Electrical shaker: Hambor G 90 shaker Germany, Softening point: Ring and ball apparatus, Air blowing apparatus: Dawson McDonald and Dawson Ltd. Infrared spectrophotometer: Pye-Unicam SP1100 Infrared Spectrophotometer.

UV-Visible Spectrophotometer

CE 1021 Ultraviolet and Visible Spectrophotometer, Cecil Instruments Ltd.

Procedure

Oxidation of qaiyarah crude oil

100g of oil were put in flask with (1-3%) of catalysts ($FeCl_3$, $ZnCl_2$ or $CoCl_2$), the oxidation was achieved by connecting a current of air with a flow rate ($120\text{cm}^3/\text{min}$). The mixture was heated to (250, 300 or 350°C) for (1, 2 or 3) hr.

Separation of asphaltenes

As in ref.^[12].

Measurement of softening point

As in ref.^[13].

Determination of H_2S

As in ref.^[14].

Vacuum distillation of oxidation oil

Heavy crude oil vacuum bottom was prepared as in ref.^[15].

Preparation of activated carbon

10g of oxidation Qaiyarah vacuum bottom were put in a reaction (stainless steel coated with nickel) with KOH (0.5:1, 1:1, 2:1 or 3:1) (KOH: residue) and were added to 25ml of distilled water.

The mixture was heated gradually -with stirring the mixture mechanically- to 350°C for 2 hr. until gas evolution was stopped, then the heating continued to $550\pm 250^\circ\text{C}$ for (1, 2 or 3) hr.

Purification of activated carbon:

Contamination of active carbon with KOH was removed by washing with water several times and checked that by litmus paper, then the sample was dried at $100-110^\circ\text{C}$ for 5hr. After that the sample was refluxed with 10% HCl solution for 1hr. The reflux sample was washed with distilled water to remove any trace of HCl.

The product was dried at $100-120^\circ\text{C}$ for 24hr and finally was crushed and sieved to 20-40 meshes using sieve from Retscl Germany.

Other relevant determination

The activity of the prepared and commercial grade carbon was assessed through adsorption of iodine and methylene blue from aqueous solution, using an already published method^[16,17]. While ad-

sorption of organic acids from aqueous solution using a published method^[18].

Measuring the bulk density was determined by an already published method^[19]. H₂S evolved from carbonization reaction was trapped with CdSO₄ saturated solution traps. The amount of H₂S was determined from the quantity of CdS precipitated.

Determination of humidity content

1g of active carbon was wetted with quantity of water, filtered and was accurately weighed to 1×10⁻⁴g, placed in a furnace at 150°C for 4hr, cooled to room temperature and accurately weighed, Humidity content was then calculated.

Determination of ash content

1g of active carbon was put in a crucible and placed in a muffle furnace at 900-1000°C for 3hr, cooled to room temperature and accurately weighed. Ash content was then calculated.

Determination of the mechanical resistance

10g of activated carbon(20-30meshes) was rotated in a cylinder containing iron balls(25 balls weighing 5.3g with 0.72cm³ volume).

The circle of rotation for 1 minute about 100, 250, 500 and 1000 circle respectively. The crushed

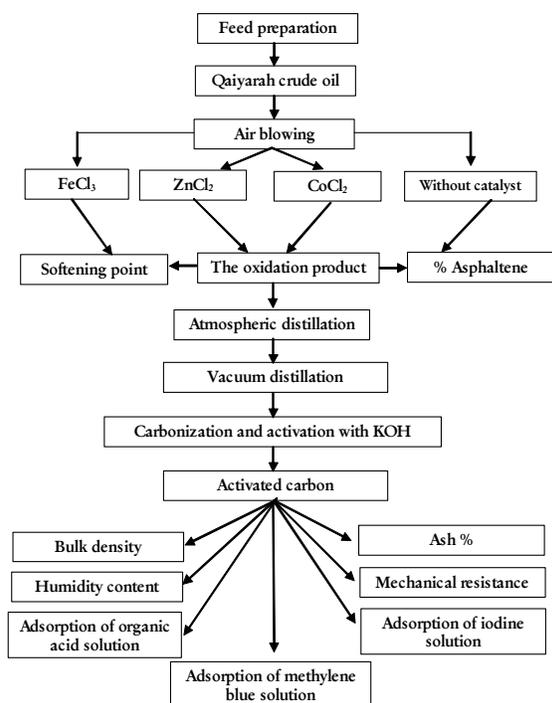


TABLE 1: The physical and chemical properties of the products obtained by air oxidation of Qaiyarah heavy oil under different condition without catalyst

Sample	Time hr.	Temp. °C	H ₂ S gm	Asphal-tene%	Softing Point °C
M ₁	1	250	0.4130	10.8	12
M ₂	2	250	0.5121	11.1	12
M ₃	3	250	0.5714	20.5	23
M ₄	1	300	0.3924	11.5	13
M ₅	2	300	0.4131	15.5	16
M ₆	3	300	0.6212	25.1	43
M ₇	1	350	0.4153	15.3	15
M ₈	2	350	0.8213	17.2	16
M ₉	3	350	0.6291	27.0	45

TABLE 2: The physical and chemical properties of the products obtained by air oxidation of Qaiyarah heavy oil under different condition with CoCl₂ catalyst

Samp.	Cata-lyst%	Time hr.	Temp °C	H ₂ S gm	Asphalte ne%	Softing point°C
1	1	1	250	0.3969	11.2	13
2	1	2	250	0.5650	12.0	15
3	1	3	250	0.4094	25.2	27
4	2	1	250	0.4100	14.5	21
5	2	2	250	0.4588	14.2	18
6	2	3	250	0.4728	23.2	34.5
7	3	1	250	0.3964	11.4	13
8	3	2	250	0.3617	23.1	33
9	3	3	250	0.4300	29.8	26
10	1	1	300	0.4818	10.8	12
11	1	2	300	0.4019	13.5	17
12	1	3	300	0.4462	18.3	23
13	2	1	300	0.3858	11.7	14
14	2	2	300	0.7345	24.9	42.5
15	2	3	300	0.3930	21.9	24
16	3	1	300	0.4011	22.5	25
17	3	2	300	0.4916	21.7	26
18	3	3	300	0.4489	22.7	32
19	1	1	350	0.5135	12.0	15
20	1	2	350	0.3790	25.1	36
21	1	3	350	0.3893	31.5	59
22	2	1	350	0.4137	12.2	16
23	2	2	350	0.8864	22.7	23
24	2	3	350	0.8923	23.4	39
25	3	1	350	0.5197	23.1	30
26	3	2	350	0.6122	22.9	32
27	3	3	350	0.6925	26.3	44

activated carbon was sieved to 40meshes, Mechanical resistance was then calculated.

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TABLE 3: The physical and chemical properties of the products obtained by air oxidation of Qaiyarah heavy oil under different condition with $ZnCl_2$ catalyst

Samp.	Catalyst%	Time hr.	Temp °C	H ₂ S gm	Asphaltene%	Softening point°C
55	1	1	250	0.6143	11.8	15
56	1	2	250	0.5301	21.8	55
57	1	3	250	0.5069	25.3	42.5
58	2	1	250	0.5628	20.3	25
59	2	2	250	0.5160	23.3	28.5
60	2	3	250	0.7291	26.6	45
61	3	1	250	0.5383	18.3	23.5
62	3	2	250	0.4898	20.9	26
63	3	3	250	0.6955	39.2	74
64	1	1	300	0.7359	19.7	28.5
65	1	2	300	0.7122	23.9	40
66	1	3	300	1.3920	38.2	68.5
67	2	1	300	1.0294	24.2	35
68	2	2	300	0.6041	44.7	84.5
69	2	3	300	0.6502	43.9	88.5
70	3	1	300	0.7392	22.7	38
71	3	2	300	1.3890	29.8	53
72	3	3	300	1.1525	58.2	110
73	1	1	350	0.6266	33.5	55
74	1	2	350	1.1526	32.1	53
75	1	3	350	0.5301	36.0	64
76	2	1	350	0.9393	31.3	52
77	2	2	350	1.2819	38.5	68
78	2	3	350	2.0347	68.8	130
79	3	1	350	0.9633	28.4	49
80	3	2	350	0.7845	31.4	59
81	3	3	350	1.8484	36.5	72.5

TABLE 4: The physical and chemical properties of the products obtained by air oxidation of Qaiyarah heavy oil under different condition with $FeCl_3$ catalyst

Samp.	Catalyst%	Time hr.	Temp °C	H ₂ S gm	Asphaltene%	Softening point°C
55	1	1	250	0.6143	11.8	15
56	1	2	250	0.5301	21.8	55
57	1	3	250	0.5069	25.3	42.5
58	2	1	250	0.5628	20.3	25
59	2	2	250	0.5160	23.3	28.5
60	2	3	250	0.7291	26.6	45
61	3	1	250	0.5383	18.3	23.5
62	3	2	250	0.4898	20.9	26
63	3	3	250	0.6955	39.2	74
64	1	1	300	0.7359	19.7	28.5
65	1	2	300	0.7122	23.9	40
66	1	3	300	1.3920	38.2	68.5
67	2	1	300	1.0294	24.2	35
68	2	2	300	0.6041	44.7	84.5
69	2	3	300	0.6502	43.9	88.5
70	3	1	300	0.7392	22.7	38
71	3	2	300	1.3890	29.8	53
72	3	3	300	1.1525	58.2	110
73	1	1	350	0.6266	33.5	55
74	1	2	350	1.1526	32.1	53
75	1	3	350	0.5301	36.0	64
76	2	1	350	0.9393	31.3	52
77	2	2	350	1.2819	38.5	68
78	2	3	350	2.0347	68.8	130
79	3	1	350	0.9633	28.4	49
80	3	2	350	0.7845	31.4	59
81	3	3	350	1.8484	36.5	72.5

RESULTS AND DISCUSSION

The diagram below helps the sequence of the materials presented in this paper.

The percentage of asphaltene and the softening point for Qaiyarah crude oil oxidized in this study showed; 27% and 45°C respectively. While after oxidation for 3hr. in presence of 2% $FeCl_3$ equals 68.8% asphaltenes and the softening point 130°C.

The aim of oxidation process with air is to increase their condensed polynuclear aromatic ring systems^[19] and carbon content.

The physical and chemical properties of oxidation processes were given in TABLES 1,2,3 and 4

below.

It is therefore obvious from TABLE 1-4 that the results are varying and indicate that the sulphur and its free radical reaction in presence of catalyst to connect the hydrocarbon chains especially at 350°C. The reason for this varying result is due to using different Lewis catalyst having different ionic size and charge. The priority is shown as follows:



IR spectrum to be strong that the appearance of band at $1700cm^{-1}$ belongs to carbonyl groups and $3450cm^{-1}$ to hydroxyl phenolic groups in comparison to the untreated Qaiyarah crude oil. The details of carbonization, activation of modified Qaiyarah

TABLE 5: The properties of active carbon prepared from the vacuum residual oxidated without catalyst

Sample	Vacuum residues : KOH	Time hr.	Density (g/cm ³) at 25°C	Ash %	Iodine number (mg/g)	Methylene blue (mg/g)	Humidity %
K ₁	1:0	1	0.712	1.130	48	9	0.89
K ₂	1:0.5	1	0.461	1.230	96	12	0.93
K ₃	1:1	1	0.456	1.800	171	15	1.23
K ₄	1:2	1	0.423	2.010	322	25	1.19
K ₅	1:3	1	0.405	3.010	423	50	1.45
K ₆	1:0	2	0.694	1.203	53	11	1.07
K ₇	1:0.5	2	0.452	1.420	143	11	1.32
K ₈	1:1	2	0.434	1.910	189	15	1.45
K ₉	1:2	2	0.402	2.510	425	29	1.39
K ₁₀	1:3	2	0.391	3.420	255	49	1.67
K ₁₁	1:0	3	0.709	1.330	51	8	1.24
K ₁₂	1:0.5	3	0.432	1.420	192	19	1.52
K ₁₃	1:1	3	0.421	2.100	318	21	1.69
K ₁₄	1:2	3	0.303	2.890	616	51	1.83
K ₁₅	1:3	3	0.321	3.510	575	53	1.81
C ₁			0.345	3.200	908	90	0.80
B.D.H							
C ₂			0.325	3.9	61.5	34.8	0.62
Russ.							

TABLE 6: The properties of active carbon prepared from the vacuum residual oxidated with CoCl₂

Sample	Vacuum residues: KOH	Time hr.	Density (g/cm ³) at 25°C	Ash %	Iodine number (mg/g)	Methylene blue (mg/g)	Humidity %
C _n	1:0	1	0.690	1.210	60	9	0.89
A ₁	1:0.5	1	0.460	2.521	170	15	1.11
A ₂	1:1	1	0.450	3.121	175	13	1.210
A ₃	1:2	1	0.370	3.901	480	35	1.89
A ₄	1:3	1	0.340	3.326	500	40	1.84
C _n	1:0	2	0.670	1.860	63	8	0.8
A ₅	1:0.5	2	0.430	3.210	216	20	1.11
A ₆	1:1	2	0.430	3.361	250	20	1.21
A ₇	1:2	2	0.470	3.442	539	59	1.32
A ₈	1:3	2	0.320	3.569	750	78	2.01
C _n	1:0	3	0.660	2.005	64	10	0.99
A ₉	1:0.5	3	0.460	3.421	260	30	1.01
A ₁₀	1:1	3	0.430	3.670	290	32	1.03
A ₁₁	1:2	3	0.430	3.517	512	40	1.71
A ₁₂	1:3	3	0.330	3.760	776	81	1.83
C ₁			0.345	3.200	908	90	0.80
B.D.H							
C ₂			0.325	3.900	61.5	34.8	0.62
Russ.							

crude oil with KOH are given in TABLES 5,6,7 and

TABLE 7: The properties of active carbon prepared from the vacuum residual oxidated with ZnCl₂

Sample	Vacuum residues : KOH	Time hr.	Density (g/cm ³) at 25°C	Ash %	Iodine number (mg/g)	Methylene blue (mg/g)	Humidity %
C _n	1:0	1	0.690	1.120	70	10	1.11
B ₁	1:0.5	1	0.450	1.290	208	15	1.13
B ₂	1:1	1	0.450	2.320	250	18	1.00
B ₃	1:2	1	0.360	2.680	507	40	1.02
B ₄	1:3	1	0.340	3.180	510	42	1.21
C _n	1:0	2	0.670	1.980	75	11	1.81
B ₅	1:0.5	2	0.420	2.210	250	17	1.67
B ₆	1:1	2	0.400	2.520	350	25	1.21
B ₇	1:2	2	0.350	3.210	682	50	2.13
B ₈	1:3	2	0.310	3.490	808	70	2.21
C _n	1:0	3	0.670	2.000	76	11	1.10
B ₉	1:0.5	3	0.420	2.240	265	18	1.23
B ₁₀	1:1	3	0.400	2.670	345	29	1.51
B ₁₁	1:2	3	0.330	3.220	710	70	1.90
B ₁₂	1:3	3	0.300	3.510	914	100	2.52
C ₁			0.345	3.200	908	90	0.80
B.D.H							
C ₂			0.325	3.90	61.5	34.8	0.62
Russ.							

TABLE 8: The properties of active carbon prepared from the vacuum residual oxidated with FeCl₃

Sample	Vacuum residues : KOH	Time hr.	Density (g/cm ³) at 25°C	Ash %	Iodine number (mg/g)	Methylene blue (mg/g)	Humidity %
C _n	1:0	1	0.660	1.600	70	12	1.1
D ₁	1:0.5	1	0.430	2.210	250	30	1.1
D ₂	1:1	1	0.430	2.561	347	38	1.3
D ₃	1:2	1	0.330	3.210	703	90	1.6
D ₄	1:3	1	0.310	3.321	700	95	1.7
C _n	1:0	2	0.640	1.924	73	13	1.8
D ₅	1:0.5	2	0.420	2.431	270	35	0.8
D ₆	1:1	2	0.410	2.671	423	60	1.1
D ₇	1:2	2	0.320	2.752	900	110	2.2
D ₈	1:3	2	0.380	3.412	625	80	1.9
C _n	1:0	3	0.620	2.031	75	15	1.8
D ₉	1:0.5	3	0.410	2.400	308	36	1.9
D ₁₀	1:1	3	0.390	2.781	451	81	1.6
D ₁₁	1:2	3	0.250	3.121	1050	250	3.2
D ₁₂	1:3	3	0.390	3.562	600	70	1.8
C ₁			0.345	3.200	908	90	0.80
B.D.H							
C ₂			0.325	3.90	61.5	34.8	0.62
Russ.							

8. It is obvious that the KOH acts as etching in the activation processes^[20].

The activity of the prepared, chemically activated carbon was assessed by iodine and methylene blue adsorption. The results indicate gradual relative increasing in adsorption as the percentage of KOH increases.

The results of other relevant measurements on

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TABLE 9: The percentage of mechanical properties of some active carbon

Sample	Mechanical Resistance			
	100 r.p.m	250 r.p.m	500 r.p.m	1000 r.p.m
K ₁₄	70.216	40.631	25.419	15.102
K ₁₅	72.352	43.225	30.814	20.347
A ₄	60.461	31.315	20.15	15.551
A ₈	55.732	20.267	18.813	12.641
B ₈	70.321	44.104	28.561	20.243
B ₁₂	65.427	35.114	25.635	20.109
D ₇	56.530	17.863	13.525	9.104
D ₁₁	50.829	15.541	10.229	5.326
C _n (1:0) ZnCl ₂	85.464	74.195	65.911	44.215
C _n (1:0) CoCl ₂	80.622	73.611	55.211	32.310
C _n (1:0) FeCl ₃	76.253	50.217	39.454	23.825
C _i B.D.H	80.000	54.000	33.000	17.000
C ₂ B.D.H	76.700	54.800	28.100	4.100

TABLE 10 : Weight and absorbed acetic acid by 1gm active carbon

Sample	Weight and adsorbed acetic acid % (by using different weights of acetic acid)					
	0.1200	0.1800	0.3000	0.4960	1.0000	2.0010
K ₁₄	0.0373	0.0451	0.0411	0.0453	0.0549	0.0556
	31.0900	25.1000	13.7200	9.1400	5.4900	2.7700
A ₁₂	0.0360	0.0403	0.0435	0.0537	0.0563	0.0574
	30.000	22.3900	14.5300	10.8300	5.6300	2.8600
B ₁₂	0.0582	0.0586	0.0608	0.0598	0.0591	0.0582
	48.5100	32.6100	20.2900	12.0500	5.9100	2.9000
D ₁₁	0.0723	0.0804	0.0979	0.1185	0.1782	0.1751
	60.3100	44.7100	32.6400	23.9100	17.8200	8.7500
C _i	0.0363	0.0386	180.03	0.0396	0.0382	0.0379
B.D.H	30.2500	21.4400	12.7000	7.9800	3.8200	1.8900

the prepared activated carbon(ash%, density and humidity%). All of these measurements supplement the general conclusion related to quality, FeCl₃ to excel the other as:

FeCl₃ > ZnCl₂ > CoCl₂ > without catalyst

TABLE 9, represents the mechanical resistance of the prepared active carbon: The results indicate delicate mechanical resistance due to the chemical treatment.

The determination of sulphur content in preparing the activated carbon, by bomb method^[14] indicates that the percentage of the sulphur contained is eliminated by 80-85%. This developed the adsorp-

TABLE 11: Weight and absorbed oxalic acid by 1gm active carbon

Sample	Weight and adsorbed oxalic acid % (by using different weights of oxalic acid)					
	0.0900	0.1350	0.2250	0.3720	0.7500	1.5010
K ₁₄	0.0226	0.0304	0.0347	0.0429	0.0406	0.0407
	25.2100	22.5300	15.4300	11.5400	5.4200	2.7100
A ₁₂	0.0246	0.0260	0.0351	0.0349	0.0313	0.0345
	27.3400	19.2600	15.6100	9.4000	4.1800	2.3000
B ₁₂	0.0320	0.0402	0.0500	0.0500	0.0636	0.0637
	35.6500	29.8100	22.2300	15.7200	8.4900	4.2400
D ₁₁	0.0353	0.0518	0.0688	0.0688	0.0929	0.0810
	39.2800	38.4300	30.5800	18.3500	18.3900	5.4000
C _i	0.0297	0.0405	0.0486	0.0665	0.0588	0.0466
B.D.H	33.0000	30.0000	21.6000	17.8700	7.8400	3.1100

TABLE 12: Weight and absorbed malonic acid by 1gm active carbon

Sample	Weight and adsorbed malonic acid % (by using different weights of malonic acid)					
	0.1040	0.1560	0.2600	0.4300	0.8670	1.7340
K ₁₄	0.0273	0.0322	0.0291	0.0300	0.0417	0.0304
	26.3400	20.6900	11.2100	6.9700	3.6500	1.7500
A ₁₂	0.0295	0.0338	0.0450	0.0448	0.0487	0.0400
	28.4200	21.7200	17.3400	12.0010	5.6200	2.3110
B ₁₂	0.0379	0.0527	0.0666	0.0543	0.0490	0.0482
	36.4600	33.8200	25.6200	12.6300	5.6500	2.7700
D ₁₁	0.0492	0.0640	0.0900	0.1277	0.1792	0.1714
	47.4000	41.0300	34.6400	29.7100	20.6700	9.8900
C _i B.D.H	0.0366	0.0471	0.0663	0.0739	0.0658	0.0593
	35.2000	30.1900	25.5000	17.2000	7.6000	3.4200

TABLE 13: Weight and absorbed succinic acid by 1gm active carbon

Sample	Weight and adsorbed succinic acid % (by using different weights of succinic acid)					
	0.1180	0.1770	0.2950	0.4880	0.9890	1.9680
K ₁₄	0.0323	0.0400	0.0635	0.0759	0.0851	0.0831
	27.4200	22.6400	21.1500	15.5500	8.6100	4.2200
A ₁₂	0.0341	0.0436	0.0619	0.0572	0.0628	0.0608
	28.9300	24.5100	20.9200	11.7200	6.3500	3.0800
B ₁₂	0.0431	0.0563	0.0762	0.0632	0.0818	0.0706
	36.5300	31.8200	25.8300	12.9500	7.2500	3.5800
D ₁₁	0.0573	0.0771	0.1044	0.1093	0.2014	0.2114
	48.6100	43.6100	35.3800	22.3900	20.3700	10.7400
C _i B.D.H	0.0473	0.0605	0.0682	0.0644	0.1200	0.1209
	40.0800	34.1800	23.1100	13.1900	10.1100	6.1400

tion properties of the activated carbon produced^[21].

The activity of the prepared, chemically activated

carbon was assessed by carboxylic acids adsorption (acetic, oxalic, malonic and succinic acids). The results obtained for the activity parameters of the catalyst-treated Qaiyarah crude oil with KOH expressed in terms of carboxylic acid adsorption are given in TABLES 10, 11, 12 and 13. It is clear that, the adsorption of organic acids by prepared activated carbon increasing with increases the number of carbon atoms in organic acids^[22]. Therefore, the arrangement of dicarboxylic acids as the percentage of adsorption increases will be:

Succinic > malonic > oxalic

While the adsorption of acetic acid diminishes due to the diamer phenomena.

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