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Carbonization, Activation and Description of Activated Carbon from Palm Tree Leaves

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Abstract

One of the maximum residences of activated carbon is adsorption capacity, this significance grows every day in a variety of fields. One of its examples is water treatment, processing of potable, all of those residences deliver capacity of activated carbon in smell elimination and flavor in residues of dissolved natural and color. Activated carbon was made from the carbonization of palm tree leave's stems and activated using calcium chloride, then tested with an increase in reactivity indicated by iodine adsorption test up to 68.6% reactivity increase in commercial sample and 48.7% in palm tree leaves sample. As the methods and precursors of activated carbon are very diverse and result in deferent adsorption properties, the primary test includes: carbonization of palm tree leaves, size reduction and classification of the charcoal produced, applying an iodine test on the non-activated sample, activating another sample with activating agent $CaCl_2$ to comparison between the activated carbon and the non-activated carbon and shows the increasing in the adsorption capacity for elemental iodine in activated carbon.

Keywords

Palm Tree, Activated Carbon, Adsorption, Calcium Chloride, Carbonization, Activation, Iodine Test

1. Introduction

Basic of activated carbon is a mainly amorphous, very porous, excessive surface-region adsorptive substance. It is mostly made up of aromatic carbon atom combinations linked together via way of means of random cross-linkages. The difference between the graphite, carbon and activated carbon, the activated carbon has groups or atoms which are piled erratically and in an unorganized fashion. Depending at the beginning uncooked fabric and thermal history, the de-

gree of order varies steam-activated coal has fairly organized graphitic platelets, whereas chemically activated wood has more amorphous aromatic structures. Random bonds have numerous fractures, fissures, and voids between the carbon layers. Activated carbon's molecular length porosity and the ensuing tremendous inner floor location make this cloth extraordinarily powerful for adsorbing a huge variety of impurities formation, including the producing of unsightly taste and odor, growing chlorine call for and formation of disinfection through products [1] [2] [3]. Its numerous applications, along with the more severe constraints imposed by new regulatory regulations on the topic on the polluted, have resulted in a massive increasing in using at activated carbon. When the amount of contaminants is less than a few hundred parts per million, processing with activated carbon is frequently less luxurious than different purification systems, like scrubbing, catalytic reheating or thermal, or adsorption processes [4]. The adsorption process is a sophisticated phenomenon that is entirely dependent on the nature of the adsorption or may be chemistry, adsorbate, and the conditions of each device phases. It is the most cost-effective and environmentally friendly method for treating water or wastewater for the specific toxins that are present. Its numerous applications, along with the more severe constraints imposed by new regulatory regulations on the topic of pollution, have resulted in a massive increase in the use of activated carbon. When the amount of contaminants is less than a few hundred parts per million, processing with activated carbon is frequently less expensive than other purifying systems, such as thermal or catalytic reheating, scrubbing, or other adsorption processes. It is the most cost-effective and environmentally friendly method for treating water or wastewater for the specific toxins that are present. In comparison to the alternative typical remedy in water pollutants reduction, it required much less funding in terms of preliminary value and land, easy work in it, safe influence, and advanced elimination of natural waste constituents [2]. The morphology of $CaCl_2$ in activated carbons had been synthesized to decorate the quantity of water vapor was adsorbing at pressuring at low (P/P_0). Possible programs for those substances are in adsorption warmness pumps and desiccant air conditioners. The ACs had been synthesized from tissue paper with the aid of using chemical activation with K_2CO_3 and the porous homes had been investigated of some of substances organized, called neath a number of activation conditions. The maximum unique floor area (SBET) (1820 m^2/g) turned into acquired from the pattern organized with a K_2CO_3/pattern ratio = 1/1 with the aid the mass using, at 900˚C will be activated for 120 min. beneath with slowly flow N_2 (2 L/min). activated by $CaCl_2$ turned into carried out the usage of 2.4 - 6.5 M $CaCl_2$ answers and an answer extent same to the pore extent of the AC. XPS floor chemical evaluation found out that the impregnated $CaCl_2$ turned into in most cases efficiently with proses are saturated even as the floor $CaCl_2$ accelerated step by step with growing quantity of impregnation. The adsorption of water vapor within-side the P/P_0 variety 0.1 - 0.three (ΔW 0.1 - 0.three) turned into dramatically ac-

celerated with the aid of using $CaCl_2$ saturated, the ΔW0.1 - 0.three cost achieving 0.fifty two g/g withinside the pattern saturated with 70 mass Cl_2; this cost is tons better than formerly stated ΔW0.1 - 0.three values [5]. The Activated carbon incorporates a extensive style of carbonized substances which have a excessive diploma of porosity and floor area. Because of its particular characteristics, it is several applications in purification of water odour, desalination, refining and commencing gases, domestic and wastewater treatment, and pollutant removal and medical applications in lots of factors of the planet. Today, numerous business wastes were accustomed supply atomic number 6 activated carbon which activation is completed each chemical and bodily. Compared with bodily activation, chemical activation is extra inexpensive because it concerns decrease activation temperature, shorter time interval and better carbon efficiency. The charcoal has a large porous system with chemical activation [6] [7]. The performance of the utility of a chemical changed activated carbon floor turned into investigated. The reason of this have a look at turned into to observe the impact of remedy with $CaCl_2$ answer at a awareness of 2000 mg^{-1} at the nitrate ions of sorption from aqueous answers in successive sorption/ remedy cycles. The sorbent turned into to begin with subjected to chemical remedy by $CaCl_2$ and eventually to the process of the sorption. The Nine cycles of absorption had been performed. The nitrate ions conc. of withinside the answer had been measured via way of means of UV-visible earlier than and after adsorption. The performance of software overall of chemical of activated carbon modified investigation ground. The effect of $CaCl_2$ solution treated at 2000 mg^{-1} which recognition on the sorption of ions nitrate from solutions the aqueous treatment cycles/ sorption. The absorption becomes first of all subjected to chemical treatment with $CaCl_2$ and in the end to the sorption process. Nine sorption cycles were performed. The concentrations of nitrate ions within the solution were measured thru manner of way of UV-vis spectrophotometry in advance than and after sorption. The effects show that treatment with $cacl_2$ delivered approximately a large growth in the share removal for each treatment step, undertaking a removal price of 80% of nitrate within the solution after 9 cyclest [7]. The diverse techniques of activated carbon covered from one of the field as agricultural and business waste fabric and diverse activation remedies the use of a comparative technique. A evaluation of several characterization strategies is likewise happened. The impact of temperature and time, activation situations, carbonization situations and the ratios impregned are defined and numerous bodily and activation chemically remedies of uncooked substances and their effect at the volume of mesoporous and micro- and floor location are discussed. Lastly, a evaluation of adsorption mechanisms of activated carbon (AC) is likewise provided [8]. One of the properties of activated carbon activated with potassium hydroxide. The effect of potassium hydroxide by conc. 1.5:1 - 0.5:1 which seeded at 773 - 973 Kelvin was studied. XRD, SEM-EDS, BET and FTIR, are using to tamarind seed symbolize belong organize the activated carbon from other. methylene blue

number, percentage yield, iodine number and initial adsorption check of Fe(III) are Proximate analysis. The adsorption of Fe(III) been more interesting in the mean in the column is 30 ml and ferric concentration are 5 - 20 mg/l. The floor purposeful businesses on carbon which is activated are C–O, C=O, O–H, $–CO_3$, Si–H and C–H. The result XRD ending confirmed excessive a potassium compound are crystal happen in activated carbon. The important factors determined withinside the activated carbon via way of means of EDS are Si, K, C and O. The adsorption of iodine and methylene blue was suggested as activated carbon at the length of pore was variation in macropore and the mesopore. In activated carbon BET figure region and the length are 67.9764 Å and 2.7167 m^2/g [9]. One of parameters of attention adsorption like charge of adsorbate in column, mattress peak of column, go with the drift pH [10]. It was discovered that the ACs are essentially microporous, with BET floor areas of 783 m^2 g^1, 1842 m^2 g^1, and 2825 m^2 g^1 for AC-1, AC-2, and AC-3, respectively [11] [12] [13] [14] [15].

2. Experimental

***Carbonizations and activation process*:**

The work are classified to three batches: batch 1: commercial charcoal, batch 2: palm tree veins, batch 3: with some condition such as 1-The raw materials for preparing 2-adsorbent include charcoal with (8-10-30) meshes, pure calcium chloride powder, Distilled water; the equipment used includes drier (furnace).

Instrumentation and measurement:

The compounds was analyzed at the Microanalytical Laboratory, Cairo University, Egypt using Jasco FT/IR 300E Fourier transform infrared spectrophotometer covering the range 400 - 4000 cm^{-1} was used to record FT-IR spectra of the ligand and its metal complexes using KBr discs. Where the chemical shifts were determined relative to the solvent peaks [16].

Prepare charcoal 1st time (patch 2):

The Palm tree veins are cut into suitable size for packing, after packing of palm tree veins, a hole is made in the top of the can for depressurizing the steam. The can is heated on stove and monitored until the gases exiting the hole can be ignited. A use of a bigger can upside down is advised and has 3 main effects. then the flammable gases (also known as wood gas) cease to exist the process is said to be almost done. After the flammable gases (also known as wood gas) cease to exist the process is said to be almost done. The hole is block by a piece of wood when let it cool. The Unpack and classify. After charcoal production, it will be crushed to small size avoid powder shape because it is very difficult to activated, the suitable size from 1.0 to 5.0 mm To activate the charcoal, The $CaCl_2$ aqueous solution with 25% in mass concentration is prepared. Then the charcoal is soaked into the aqueous solutions of $CaCl_2$ for 24 hour (1440 minute). The mixture of charcoal and $CaCl_2$ is taken out of the solution and rinsed and Placed in an oven at approximately 150˚C for 1 hr.

Prepare charcoal 2nd time (patch 3): (as same steps in batch 1st but with

some tweaks):

1) the wood chops was cut smaller to increase surface area.

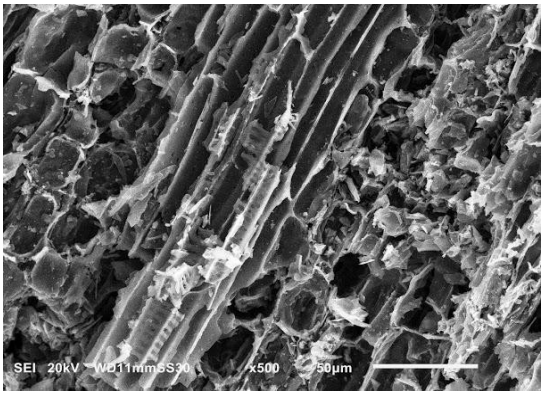
2) the insulating (big) can was used from the beginning to the end except last 5 min (to read the process stage) before it 15 min covered and before it 15 min uncovered (compared to only 30 min usage in the first experiment) Figure 1.

1. Precursor choice plam tree leaves

2. Carbonization setup

3. Size reduction

4. Activation with calcium chloride



5. Activated carbon characterization (Mixed sample batch 2 and batch 3).

6. Adsorption batch test

Figure 1. Show the summary steps of activated carbon manufacture.

Iodine solution for measuring the efficiency of activated carbon.

After taking one gram of each non-activated sample (com, 1 and 2) and placing each in a test tube, 2 ml of HCl (5%) was added to each sample to neutralize any remaining strong base ash that would react with the iodine solution, after that, a (25 ml) iodine alcohol solution (of 15.75 m molar) added in tubes testing,

shaken and left for a day, 10 ml solution were extracted from each test tube and titrated with (31.5 mmolar) sodium thiosulphate solution. the chemical reaction:

$$2Na_2S_2O_3 + I2 > Na_2S_4O_6 + 2NaI$$

As the chemical reaction progresses (yielding ***2NaI***, which doesn't have the color of iodine] the solution becomes colorless. The amount of the sodium thiosulphate used is recorded, then used to calculate how much elemental iodine was adsorbed by one gram carbon of size mesh no. 8 (non-Activated.) As a parallel procedure 5 gm of each sample were mixed with calcium chloride solution for a day, to be activated, then filtered and dried in an oven for (2 hrs) at (150˚C), one gram of each activated sample was subjected to the same iodine test and the amount of adsorbed iodin is recorded and compared with the results of the non-activated carbon.

3. Result and Discussion

FTIR analysis

According to the desk of IR absorption Figure 2, The FTIR evaluation of organized AC(PTL)$CaCl_2$ well-known shows a easy spectrum, proven on FTIR graph parent 1. The height at round 1612.70 cm^{-1} is assigned to presence of carbon-carbon bond (C=C) businesses (stretching weak) on surface. Triple ponds such as (C≡C, C≡N) businesses in organized AC(PTL)$CaCl_2$ had been showed with the aid of using the height at Around 2095.15 cm^{-1}. to the band of (C≡C) shifted little businesses turned into found in organized AC across the rang 2155.13 cm^{-1}. The presence of institution (C≡N) is showed with the aid of using the peaks found at 2360.75 cm^{-1} at the same time as the sturdy wide peak at 3354.40 cm^{-1} is because of the sturdy, large (O-H) stretching alcohol intermolecular bonded. A little shift of the bands of medium, large (O-H) stretching alcohol looks on the variety 3738.91 cm^{-1} [16].

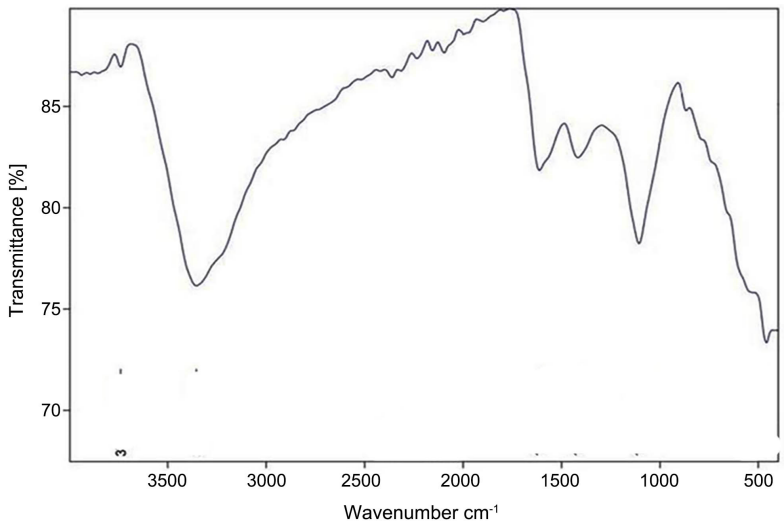


Figure 2. FTIR analysis of composite sample (batch 2 and batch 3) of Activated Carbon activated by $CaCl_2$.

The FTIR spectroscopy divided to 2 particularly area the fingerprint area and the diagnostic area that approximately degrees at (600 to 1400) and (1500 to 4000) respectively. So, the Diagnostic Region is the principal purpose to become aware of exceptional feature businesses and now no longer centered on fingerprint area because of hard evaluation and hard interpretation. observed that exist a huge variety of large with rounded tip stretching peaks in our outcomes and that in step with presence of O-H institution because of H-Bonding that make peaks now no longer sharp, weaker, and broader [17].

BET analysis

The useful of isotherms operation in adsorption have veritably range in describing the commerce at the adsorbate and the adsorbent of any system. The elements attained on the different models give important information on the mechanisms belong the sorption, the face parcels also adsorbents affections. It is more laws and equation for assaying experimental adsorption equilibrium data. The model of Freundlich and also Langmuir is one of the most acceptable adsorption faces in solute systems. The description of adsorption isotherms, adsorbate proses happen in distribution between the solid and liquid phases when the system reaches the equilibrium. The analysis of isotherm data by fitting them to different models is important to find a sustainable model that can be used for the interpretation of angles. (**Figure 3**) shows the setting of activated carbon and the isotherms N_2

Adsorption for BET Face area, total severance volume, and mean severance periphery of the set AC, as determined by adsorption/desorption isotherm of nitrogen. It was plant that the set AC has a22.113 $m^2 \cdot g^{-1}$ (BET) specific face area and 1.4×10^3 cm^3 g^1. total severance volume and other data showed in **Table 1**, the mention of area for specific surface of the raw material before the activation will be 9.0 m^2 g/l. it will be found that adsorption-desorption isotherms belong to the type (*i.e.*, isotherms I) of IUPAC classification the type(I) isotherm known as Langmuir isotherm classified as (mono layer) High affinity of absorption and adsorption are consider type of this isotherms of it or indicated that the interaction between adsorbent surface and adsorbate is relatively high (chemisorption), and that the material in question consists mostly of micropores. The distribution of the size of pore which was preparing activated carbon is plotted in (BJH-Plot). The pore volume increase, as the microporosity will increase, indicates that the most suitable pores had size about 2.5 nm [18].

Table 1. Show the adsorbent, BET, Monolayer volume, Total pore volume, Mean pore diameter, Energy constant, classification and interaction between adsorbent surface and adsorbate of activated carbon.

Adsorbent	BET Surfaced area. (m^2 g/1)	Monolayer Volume (Vm) (cm^3 (STP) g1)	Volume pore (Vp) cm^3 g/l	pore diameter (mean) dp (mm)	Energy constant c	Classification of pores (porosity)	Interaction between adsorbent surface and adsorbate
AC	22.113	5.0806	1.4×10^{-2}	2.5207	−62.37	Micropores	relatively strong

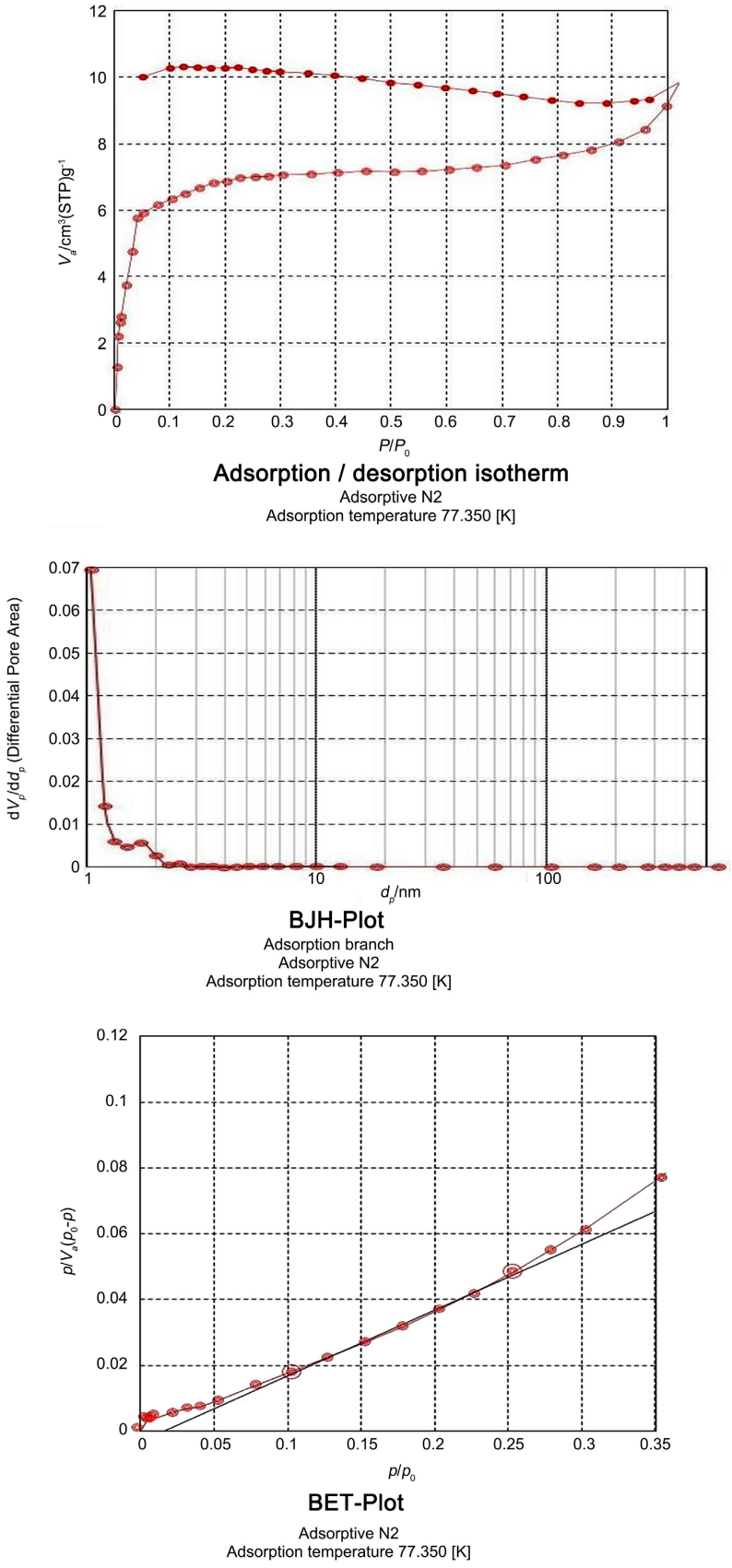


Figure 3. Show the absorption and adsorption of activated carbon.

SEM and EDX analysis

Physicochemical Properties: Surface morphologies of the prepared activated carbon which Determined by scanning electron micrographs (SEM) Figure 4 of AC the SEM images of the developed AC adsorbent. The prepared activated carbon using SEM technique analyzed the adsorption surface. Micrograph of SEM of activated carbon which activated with $CaCl_2$ porous surface was observed at higher magnification. The SEM images observed.

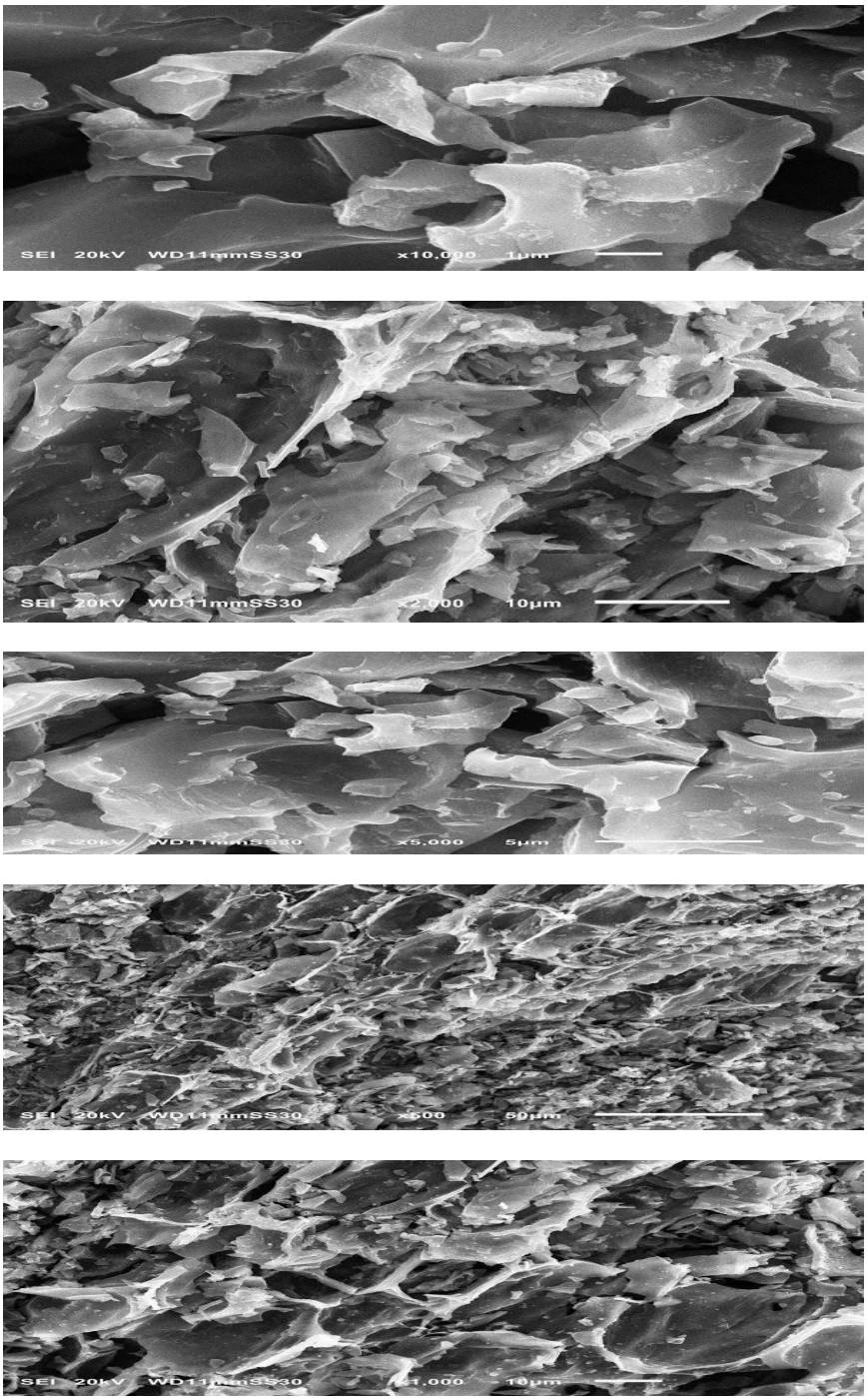


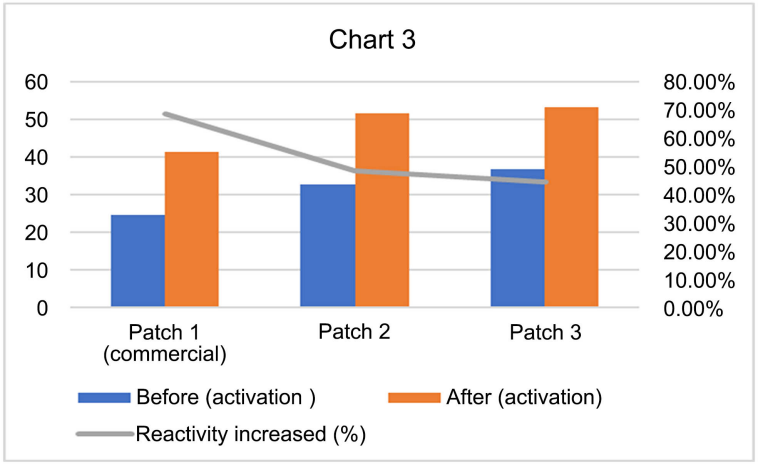
Figure 4. SEM Images (1 - 5 - 10 - 50 μm).

The pores diameter measures with micro-meter (μm) range. These images displayed the morphological properties and megascopic and microscopic textures of the AC in five magnifying stages (1000×, 2000×, 5000×, 10,000× and, 15,000×). Megascopic images (1000×, 2000× and 5000×) give the shape and size of the AC, whereas microscopic images (10,000× and 15,000×) clearly showed the elaborated surface structure of the AC.

The SEM images shows a large fragile cellulosic cavity, which in showed a lot of Ashe like parts that seems to plug the surface of the pours, as a result of the carbonization and activation conditions, compared to other SEM images from the same cellulosic material, the pores are less uniform and often plugged by Ashe like particles, but the images are showing more pores. The micro-analysis of the elemental of morphology of carbon observed EDX which observed the energy dispersive and SEM (scanning electron microscope). **Figure 4** and **Table 1** are discussion of the micrograph by SEM and composition elemental of activated carbon which activation at temperature 150˚C for one hour. The activated carbon have external surface which have fully activation with structure porous. The area of the external surface of activated carbon have pore with different diameters was distributed in the all surface. A lot of components removed from the raw material (activated by calcium chloride). The activated carbon of EDX elemental microanalysis are carbon (71%), oxygen (32%), potassium (0.99%)., calcium (2.5%), color (0.9%) and silica (0.5%), high amount of (C) corresponded with BET results but low amount of calcium and color it might because they volatile during activation process and those cause pores to be formed and presence of silica might be due to its presence in the main raw material [19].

Iodine test

The comparison between the activated carbon and the non-activated carbon showed the increasing in the adsorption capacity for elemental iodine in (patch 3) the most, and also showed highest reactivity increase in (commercial patch) **Figure 5**, **Table 2** showed the 3 patches iodine adsorption capacity before and after activation and the Gray line indicating the percentage of which the capacity increased for each patch, as expected (patch#3) had the most iodine adsorption capacity after activation (53.25 mg Iodine/gram Carbon) as before (36.85 mgI/gC), following it (patch 2) then (patch 1). this can be explained by the simi-activation of patch 2 and patch 3 in the carbonization procedure, noting that patch 3 were in higher temperature, higher pressure, and higher steam concentration than patch 2, which explain why patch 3 had more capacity than patch 2.other thing can be noticed, that the increase in capacity for each patch (reactivity increase%) is greatest in the commercial patch (+68.6%), less in patch 2 (+48.7%) and lowest in patch 3 (+44.5%). This can be allocated to different possible reasons; one could be because the activating/oxidizer agent (calcium chloride) was more suitable to the cellulosic structure of the commercial patch, which used orange tree wood as a precursor, while patch 2 and patch 3 precursor were palm tree leave's stems.



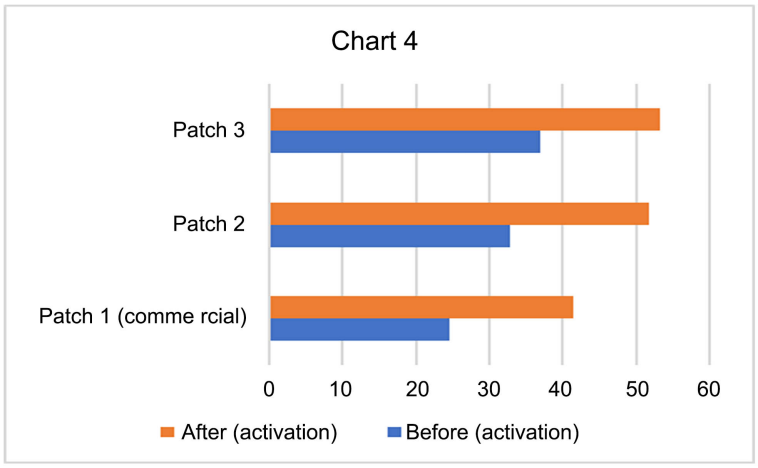


Figure 5. Chart (3 and 4) relation between charcoal before and after activation and reactivity increased (%).

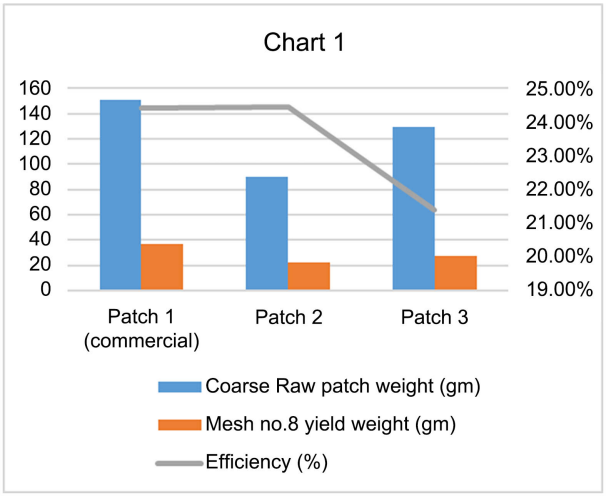
Table 2. Show the adsorbed iodine (I_2/gram carbon) in patch 1, patch 2 and patch 3 for activated carbon (before activation and after activation).

Adsorbed Iodine /I_2 gram carbon	Patch 1 (commercial)	Patch 2	Patch 3
Before (activation)	24.6 mg I_2/gC	32.76 mg I_2/gC	36.85 mg I_2/gC
After (activation)	41.475 mg I_2/gC	51.72 mg I_2/gC	53.25 mg I_2/gC

Screening and sizing:

The 3 samples namely **patch 1** (commercial (as a blank)), **patch 2** and **patch 3** (resulting from previous experiments) all were crashed by hand and screened several times to maximize the yield of the chosen size of mesh no. 8, shown in Table 3.

Figure 6 (Chart 1 and 2), showing the weight of each patch raw course input, the yield of mesh no. 8 from each raw course patch and the yield percentage of each, as can be noticed: patch 3 has less yield (21.40%) than patch 2 (24.44%), a possible reason for that could be due to the semi-activation in the manufacturing



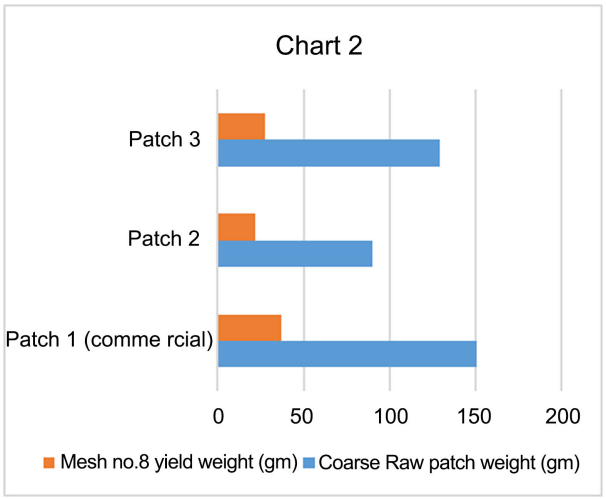


Figure 6. Chart (1 and 2) graph between course raw weight and mesh no. 8 weight.

Table 3. Includes the weight of the 3 patches and the comparison between their efficiencies.

	Patch 1 (commercial)	Patch 2	Patch 3
Coarse Raw patch weight (gm)	151.1 (gm)	90 (gm)	129.5 (gm)
Mesh no. 8 yield weight (gm)	36.87 (gm)	22 (gm)	27.7 (gm)
Efficiency (%)	24.4%	24.44%	21.4%

procedure of the charcoal, at which patch 3 was exposed to higher temperature, higher pressure and more saturation of steam, than patch 2, which in turn made more pores in the carbon structure of patch 3, making it more brittle, and susceptible to finer fragmentation upon impact in the crushing process, another possible reason or more of a disclaimer, is that the crushing processes were executed by hand, so identical crushing procedures cannot be guaranteed, and an increase in the crushing time and power in patch 3 might be the reason. None-

theless patch 1, patch 2 and patch 3 were very close in their yield (24.4%, 24.44% and 21.4% respectively.

4. Conclusion

The activated carbon manufacture is very fixable where you can carbonize any waste plant to charcoal. In this search we work in three batches 1) commercial charcoal sample, 2) vein of palm tree 3) palm tree with some precursor, when sample batch 2 and batch 3 are carbonization to have charcoal then three batches work on activation of the three. As data and result show that the best one in activation is batch 3 to have good activated carbon with efficiency.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] Kilduff, J.E., Karanfil, T., Chin, Y.P. and Weber, W.J. (1996) Adsorption of Natural Organic Polyelectrolytes by Activated Carbon: A Size Exclusion Chromatography Study. *Environmental Science Technology*, **30**, 1336-1343. https://doi.org/10.1021/es950547r

[2] Dabrowski, A. (2001) Adsorption—From Theory to Practice. *Advances in Colloid and Interface Science*, **93**, 135-224. https://doi.org/10.1016/S0001-8686(00)00082-8

[3] Gibert, O., Lefèvre, B., Fernández, M., Bernat, X., Paraira, M. and Pons, M. (2013) Fractionation and Removal of Dissolved Organic Carbon in a Full-Scale Granular Activated Carbon Filter Used for Drinking Water Production. *Water Research*, **47**, 2821-2819. https://doi.org/10.1016/j.watres.2013.02.028

[4] Din, M.I., Ashraf, S. and Intisar, A. (2017) Comparative Study of Different Activation Treatments for the Preparation of Activated Carbon: A Mini-Review. *Science Progress*, **100**, 299-312. https://doi.org/10.3184/003685017X14967570531606

[5] Okada, K., Nakanome, M., Kameshima, Y., Isobe, T. and Nakajima, A. (2010) Water Vapor Adsorption of $CaCl_2$-Impregnated Activated Carbon. *Materials Research Bulletin*, **45**, 1549-1553. https://doi.org/10.1016/j.materresbull.2010.07.027

[6] Zanella, O., Tessaro, I.C. and Féris, L.A. (2014) Study of $CaCl_2$ as an Agent That Modifies the Surface of Activated Carbon Used in Sorption/Treatment Cycles for Nitrate Removal. *Brazilian Journal of Chemical Engineering*, **31**, 205-210. https://doi.org/10.1590/S0104-66322014000100019

[7] Karnib, M., Kabbani, A., Holail, H. and Olama, Z. (2014) Heavy Metals Removal Using Activated Carbon, Silica and Silica Activated Carbon Composite. *Energy Procedia*, **50**, 113-120. https://doi.org/10.1016/j.egypro.2014.06.014

[8] Hemath Naveen, K.S., Hema Priya, M., Swathi, S.D. and Vinothan, K.G. (2017) Sewage Treatment Methodology—A Review. *International Journal of Engineering Trends and Technology* (*IJETT*), **45**. 118-120. https://doi.org/10.14445/22315381/IJETT-V45P226

[9] Heidarinejad, Z., Dehghani, M.H., Heidari, M., Javedan, G., Ali, I. and Sillanpää, M. (2020) Methods for Preparation and Activation of Activated Carbon. *Environmental Chemistry Letters*, **18**, 393-415. https://doi.org/10.1007/s10311-019-00955-0

[10] Moonsri, S.M.P., Palas, W. and Khumpai, S. (2015) Characterization and Properties of Activated Carbon Prepared from Tamarind Seeds by KOH Activation for Fe(III) Adsorption from Aqueous Solution. *The Scientific World Journal*, **2015**, Article ID: 415961. https://doi.org/10.1155/2015/415961

[11] Cazetta, A.L., Vargas, A.M.M., Nogami, E.M., Kunita, M.H., Guilherme, M.R., Martins, A.C., Silva, T.L., Moraes, J.C.G. and Almeida, V.C. (2011) NaOH-Activated Carbon of High Surface Area Produced from Coconut Shell: Kinetics and Equilibrium Studies from the Methylene Blue Adsorption. *Chemical Engineering Journal*, **174**, 117-125. https://doi.org/10.1016/j.cej.2011.08.058

[12] Elhussien, M.H., Hussein, R.M., Nimir, S.A. and Elsaim, M.H. (2017) Preparation and Characterization of Activated Carbon from Palm Tree Leaves Impregnated with Zinc Chloride for the Removal of Lead(II) from Aqueous Solutions. *American Journal of Physical Chemistry*, **6**, 59-69. https://doi.org/10.11648/j.ajpc.20170604.12

[13] Chapter 2. Wood Carbonisation and the Products It Yields. In: *Industrial Charcoal Making*, FAO. https://www.fao.org/3/x5555e/x5555e03.htm

[14] Ma, H.T., Ho, V.T.T., Pham, N.B., Nguyen, D.C., Vo, K.T.D., Ly, H.C. and Phan, T.D. (2017) Effect of the Carbonization and Activation Processes on the Adsorption Capacity of Rice Husk Activated Carbon. *Vietnam Journal of Science and Technology*, **55**, 485-493.

[15] Hussein, F.H., Halbus, A.F., Lafta, A.J. and Athab, Z.H. (2015) Preparation and Characterization of Activated Carbon from Iraqi Khestawy Date Palm. *Journal of Chemistry*, **2015**, Article ID: 295748. https://doi.org/10.1155/2015/295748

[16] El-Tabl, A.S., Wahba, M.A. and Yonues, S.M. (2016) Removal of Heavy Metals and Salmonella Pathogens from Sewage Sludge Using a Novel Chelating Agent Derived from Succino-Hydrazide and Its Reuse as a Fertilizer. *Journal of Chemistry and Chemical Sciences*, **6**, 277-292.

[17] Alia, A.E., Salema, W.M., Younes, S.M. and Elabdeen, A.Z. (2018) Ferrite Nanocomposite (Rice Straw-$CoFe_2O_4$) as New Chemical Modified for Treatment of Heavy Metal from Waste Water. *Hydrology*: *Current Research*, **10**, Article ID: 1000311.

[18] El-Tabl, A.S., Wahaab, R.A. and Younes, S.M. (2013) Downflow Hanging Sponge (DHS) Reactor as a Novel Post Treatment System for Municipal Wastewater. *Life Science Journal*, **10**, 409-414.

[19] Younes, S.M. and el Sayed, G. (2021) Use Chlorine Doses as Disinfection of Filamentous Bacteria by Eliminating Physio-Chemical Parameters in Activated Sludge Wastewater Treatment. *Journal of Chemical Science and Chemical Engineering*, **2**, 38-43.