MANUFACTURING OF ACTIVATED CARBON USING DISPOSABLE COCONUT SHELLS FOR CATALYTIC ACTIVITIES AND WATER TREATMENT UTILIZATIONS

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Abstract: Activated carbon is a black color solid compound which is fabricated using naturally occurring materials such as woods and species of coal that composed of the majority in carbon. The activated carbon is highly remarkable compound in the catalytic activities in most of chemical industries and water treatment activities because of the significant performances of such activated carbon due to the sufficiency of the surface property which is called as the adsorption with the couple of high porosity. The manufacturing of activated carbon from disposable coconut shells and the investigations of the physic-chemical characteristics of such activated carbon were the expectances of the existing research. Domestically collected coconut shells were burnt in the range of different temperatures 390–300 °C after removing unnecessary constituents. The chemical composition of the powdered activated carbon was inspected using an X-ray fluorescence (XRF) spectrophotometer and the surfaces of prepared activated carbon were examined using an optical microscope. As the outcomes of the above experiments, it seems that the most adequate burning temperature for the manufacturing of that batch of coconut shells was in the range of 330–350 °C, 68.85 % of ferrous and 31.15 % of potassium as the composed metallic element apart from the non metallic carbon and the pure black color non- composite surfaces were observed under the microscopic studies. It is encouraged to develop this production using cost effective materials such as the shells of fesults which are belonging to the palm cast while utilizing the productions through the various applications in chemical industries.
Keywords: Coconut shells, Activated carbon, Manufacturing, Compositional analysis, Industrial utilizations.

1. Introduction

Activated carbon is a solid black compound that composed with carbon as the major element usually in the form of charcoal. The visible and important characteristics of activated carbons are as follows [1–4]:

– high porous and low dense material;

– high surface area due to porous body.

Usually the activated carbons are synthesized from different raw materials as given in the below while undergoing some physic-chemical processes [1–6]:

– wood;

– varieties of natural coal;

– coconut shells;

– risk husk;

– lignite;

– saw dust;

– synthetic materials (polymers).

Activated carbons are applicable in a series of advanced chemical uses an shortlisted in the below because of the specific physic-chemical characterizations of activated carbons even though the characteristics might be varied based upon the raw materials [2–9].

– adsorption capacity of some components from gases and liquids;

– thermal resistance material (refractory);

– competences on catalytic and supportive activities for some chemical processes and reactions;

– electrical conductivity;

– robust characteristics against acidic and basic environments.

The adsorption is a surface based process which is occurring on a solid material that addicts some molecules from a material from a liquid or gaseous compound onto the surface of that solid material. The adsorbate and the adsorber are the two important components regarding the process of adsorption [3–9].

The addicting molecules which are composed in a gaseous or liquid phase are known as the adsorbates such as some volatile organic compounds (VOC's) and metallic components. The solid material that having a specific surface to occur the process of addicting extraneous molecules is known as the adsorber such as the activated carbon and some minerals [4–9].

Usually the adsorption process is occurring due to the acting of some specific electrostatic forces and Vander Waal's forces between such adsorbers and adsorbates. The adsorption capacity of some material is depended on the magnitudes of such electrostatic forces and the expansion of the surface area of the adsorber. The relatively higher surface area of activated carbon is a useful quality for an adsorber and it is an adjustable property under going some processes as shown in the Fig. 1 [3–9].

Activated carbons are usually prepared in granular, powdered and pallets. The activation of such activated carbons materials could be enhanced using some well developed advanced methods that namely as physical method and chemical method. In the chemical activation method, the raw materials will be impregnated using a specific chemical agent such as ZincChloride and the impregnated materials will be pyrolysed. In the physical activation method, the raw materials will be carbonized under inert conditions using gasification and the carbonized materials will be treated with a mix of steam and carbon dioxide. Usually under both processes the micro-porosity/surface area of activated carbon will be increased [1–5].

The pyrolysis is the combustion of materials when absence of oxygen and the process is bit expensive and higher amount of heat should be supplied in a system of reactors. The gasification is a partial combustion of some material in the way of converting the materials into combustible gases such as the hydrocarbons [1–4].

A catalytic activity is an enhancement of the rate of some specific reaction because of the reduction of the typical activation energy of such reaction due to the impact of some external chemical compound or agent. The chemical compound or agent that causes the enhancement of the reaction rate is called as the catalyst [1–6]. There are two processes of catalysis have been defined based on the phases of reactions and phases of catalysts as described in **Table 1**.

Table 1
Processes of catalysis

Homogeneous Catalysis	Solid State Catalysis(Heterogeneous Catalysis)
The catalysts which are soluble in the solvents	Motivate the reaction when the reactants are remaining in the gaseous or liquid phase while contacting with a solid material
	The adsorption is the key process in the solid state catalysis
The chemical structures of such catalysts are complexes	The large surface area and the high porosity are essential requirements for the contact solid material
Ex-Wilkinson catalyst, Ziegler-Natta catalyst	Ex- Ni/Fe/Cu supported activated carbon

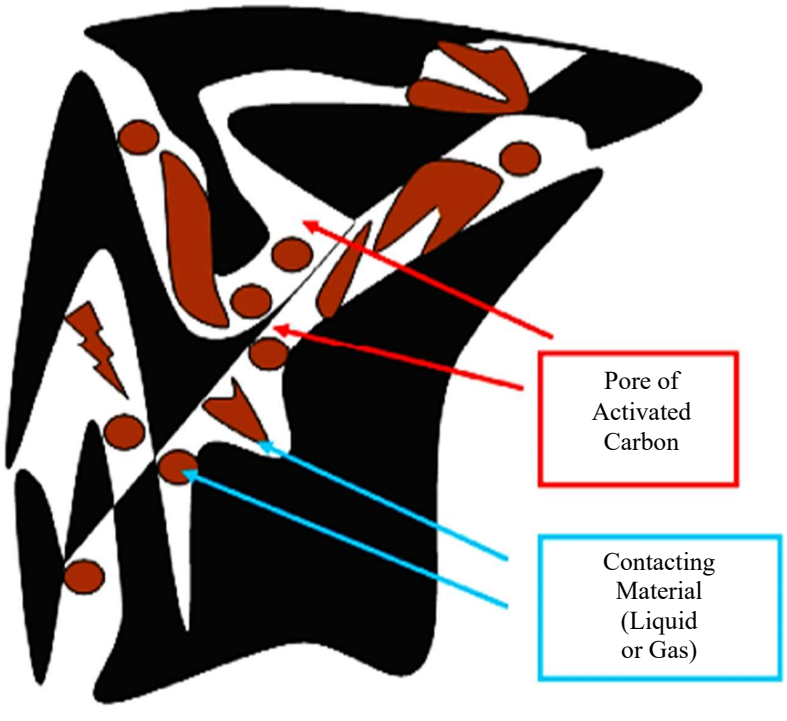


Fig. 1. Internal structure and body of activated carbon

2. Methods

The sample preparation methodology have been short-listed in the below:

– cleaning of the collected disposable coconut shells removing the remaining kern and refuses of the shells;

– breaking of cleaned coconut shells into small fragments.

The coconut shell fragments were oven dried utile removal of moisture under the temperature 105 °C.

– there were arranged a few of similar sets from dried coconut shells based on the outlook of the confirmation of most suitable firing temperature or a range of temperature;

– the arranged sets were fired using a muffle furnace in different temperatures as given in the below for 30 minutes:

–Set 1–390 °C;
–Set 2–360 °C;
–Set 3–350 °C;
–Set 4–330 °C;
–Set 2–320 °C;
–Set 2–300 °C;

– the fired coconut shell fragments were allowed to gently cool and the cooled coconut shell fragments were comminuted using a ceramic crucible into small allotments especially in the sizes 2–5 mm which is called as the activated carbon;

– the prepared activated carbons were characterized using X-ray fluorescence (XRF) spectrophotometer and optical microscope.

3. Results

There were confirmed that the most appropriate range of temperature for the firing for this batch of coconut shells was 330 °C–350 °C. However, the above temperature or the range may be slightly or significantly varied with the batch of coconut shells which is collected from different country/region and environmental conditions such as the pressure, humidity etc. The prepared activated carbons were shown in the **Fig. 2.**

Fig. 2. Prepared activated carbon

Elemental chemical compositions of prepared activated carbon according to the X-ray fluorescence (XRF) analysis are given in the **Fig. 3** and **Table 2.**

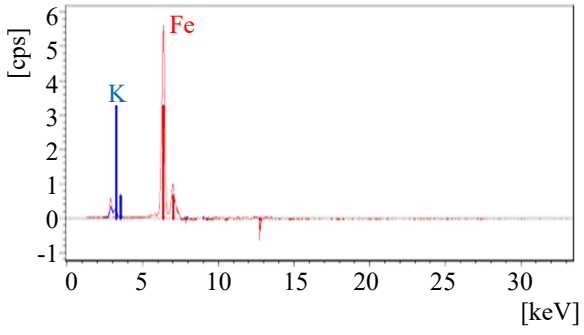
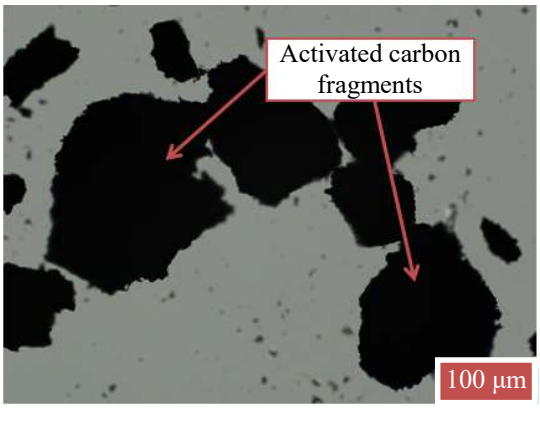
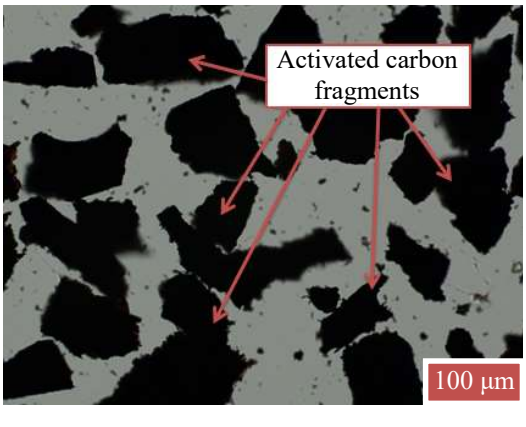


Fig. 3. X-ray fluorescence (XRF) spectroscopy of prepared activated carbon

Some important microstructures views of prepared activated carbons were shown in the **Fig. 4.**



a



b

Fig. 4. The microstructures of prepared activated carbons: *a* – large fragments and *b* – medium and small fragments

Table 2

Elemental composition of prepared activated carbon

Color	Element	Atomic Number (amu)	Content (%)
	Iron (Fe)	26	68.85
	Potassium (K)	19	31.15

4. Discussion

The acidity of such activated carbon may be relatively greater because of the presence of Potassium as 31.15 %. The prepared activated carbon may have high adsorption capacity for some other metals because of the presence of 68.85 % of Fe. However the adsorption capacity for some metals of such activated carbon could be exactly presumed after analyzing of the Fe mineralogy in such activated carbon such as marcasite, glauconite and pyrite [3–9]. Usually the prepared activated carbon should be applicable in following industrial uses in the treatment of waste water:

– removal of heavy metals from waste water;
– removal of organic pollutants from waste water;
– removal of unsavory odor and abnormal color from the waste water.

According to the microscopic analysis, mainly some non-contaminated black surfaces were observed from prepared activated carbon. The porosity and some other surfaces characteristics and some composites should be further characterized using some advanced microscopic analytical technique. The black color activated carbon pallets were observed [2–8].

The relatively higher Fe content would be useful in the activities of solid state and the prepared activated carbon should be applicable in following chemical processes with or without some modifications [2–10]:

– oxidation processes;
– ozonation processes;
– derivation and extraction processes;
– dehydrate processes;
– manufacturing of fertilizer.

5. Conclusion

The most suitable temperature range for the manufacturing (burning) of activated carbon was 330–350 °C for this batch of coconut shells. The manufactured activated carbons were composed with 68.85 % of Fe and 31.15 % of K as the metallic elements apart from nonmetallic carbon. There were observed non- contaminated black surfaces. The manufactured activated carbon may have high adsorption capacity. The manufactured activated carbon could be used as a solid state catalyst for some chemical processes with or without chemical processes with or without modifications. Some of thermal treatments should be done to enhance the catalytic strength of such activated carbons such as treating with inert gases.

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References

1. Lima, S. B., Borges, S. M. S., Rangel, M. do C., Marchetti, S. G. (2013). Effect of Iron Content on the Catalytic Properties of Activated Carbon-Supported Magnetite Derived from Biomass. Journal of the Brazilian Chemical Society, 24 (2), 344–354. doi: http://doi.org/10.5935/0103-5053.20130044
2. Gomes, H. T., Miranda, S. M., Sampaio, M. J., Silva, A. M. T., Faria, J. L. (2010). Activated carbons treated with sulphuric acid: Catalysts for catalytic wet peroxide oxidation. Catalysis Today, 151 (1-2), 153–158. doi: http://doi.org/10.1016/j.cattod.2010.01.017

3. Guiza, M., Abdedayem, A., Ghouma, I., Ouederni, A. (2017). Effect of copper and nickel supported activated carbon catalysts on the simultaneous adsorption/ozonation process of nitrobenzene degradation. Journal of Chemical Technology and Metallurgy, 52 (2), 836–851.
4. Bharadwaj, N. D., Mishra, P., Jain, R., Uchchariya, D. (2016). Use of Activated Carbon of Coconut Shell (Cocosnucifera) for Reduction of Chloride and Hardness of Water. International Advanced Research Journal in Science, Engineering and Technology, 3 (8), 85–90.
5. Scholz, M., Martin, R. J. (1997). Ecological equilibrium on biological activated carbon. Water Research, 31 (12), 2959–2968. doi: http://doi.org/10.1016/s0043-1354(97)00155-3
6. Velten, S., Hammes, F., Boller, M., Egli, T. (2007). Rapid and direct estimation of active biomass on granular activated carbon through adenosine tri-phosphate (ATP) determination. Water Research, 41 (9), 1973–1983. doi: http://doi.org/10.1016/j.watres.2007.01.021
7. Dąbrowski, A. (2001). Adsorption – from theory to practice. Advances in Colloid and Interface Science, 93 (1-3), 135–224. doi: http://doi.org/10.1016/s0001-8686(00)00082-8
8. Walker, G. (1999). Biological activated carbon treatment of industrial wastewater in stirred tank reactors. Chemical Engineering Journal, 75 (3), 201–206. doi: http://doi.org/10.1016/s1385-8947(99)00109-6
9. Slejko, F. L. (1985). Adsorption technology. New York: Marcel Dekker Publication, 240.
10. Renou, S., Givaudan, J. G., Poulain, S., Dirassouyan, F., Moulin, P. (2008). Landfill leachate treatment: Review and opportunity. Journal of Hazardous Materials, 150 (3), 468–493. doi: http://doi.org/10.1016/j.jhazmat.2007.09.077

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