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Physio-chemical characteristics, decoloring and antibacterial activity of activated carbon prepared from Corn *maize* and *Doum fruit*

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ABSTRACT

Sudan is one of the large agriculture- based countries. In this study activated carbon was prepared using two agriculture waste of Sudanese seeds namely Corn maize and Doum fruit . The carbonization of the materials was done at 350^{o}C for two hours and allowed to cool at room temperature then followed by activation withKOH . The results showed that the carbon percentage of doum fruit and Corn maize were 35.13% 49.42respectively. Porosity of both samples were is in the range from 57-60%, Fourier- Transform Infrared Spectroscopy was used to determine the functional groups of both samples. The results showed a strong and broad adsorption peak at1577.66cm^{-1}, which corresponds to the lactone in doum samples, Conjugate carbonyl was observed at 1595.20 cm^{-1} for the same sample. The main functional groups of C-O and aliphatic CH_2 were found in corn maize sample. Physical properties of activated carbon prepared from doum fruit indicate a pH of 7.8 and volatile matter of 24.3% while activated carbon prepare from corn maize has a pH of 7.6 and volatile matter of 23.0%. Corn maize activated carbon showed a better decoloring activity as it was able to remove 54 % of methylene blue color within 24 hours. On the other hand activated carbon from doum samples showed a better antibacterial activity against E. Coli in contaminated water samples.

Key words: Activated carbon, corn maize, doum, physio-chemical characterization, antibacterial activity, decoloring efficacy, Sudan.

INTRODUCTION:

Activated carbon, also widely known as activated charcoal or activated coal is a form of carbon which has been processed to make it extremely porous and thus to have a very large surface area available for adsorption and chemical reactions[1]

Materials to be potential precursors of activated carbons should have a high carbon content and low inorganic compound levels[2]in order to obtain a better yield during the carbonization processes. This is valid for practically every lignocellulosic waste. A large number of agricultural materials have been used for preparation of activated carbon for example, corncob, corn grain, avocado, mango, orange, and guava seeds[2-4] , lignite[5]and rosewood sawdust[6].

Activated carbon (AC) has been widely used in various industrial areas such as air pollution control, wastewater treatment to remove various pollutants , it is used in filters in gas masks and even in water treatment systems of hospital renal haemodialysis care units[5],[7].

An additional important benefit of activated carbon –which is nowadays gaining a great concern- is its use as a decoloring substance for removal of dyes discharged from dyeing industries into the water which may be an important source of pollution. These dyes are toxic to fish and other aquatic life and even may have a mutagenic and carcinogenic effect[8-10].They can also cause severe damage to human beings, such as dysfunction of kidney, reproductive system, liver, brain and central nervous system [9],[11].

Several studies showed that carbon produced from lignocellulosic precursors have been used to eliminate basic dyes[3],[12]..

Activated carbon has also been found to have the ability to remove bacteria like *Pseudomonas aeruginosa* and *Escherichia Coli* from fresh and potable water systems [7] ,[13].

Qualitative and quantitative analysis of activated carbon prepared from agricultural waste materials give useful data about its composition.Proximate analysis provides an approach to estimate the content of various parameters such as moisture; volatile matter; fixed carbon, ash, iodine number and pore size. Elemental analysis through Infrared Spectroscopy (IR)for the main functional groups on carbon surface is a common and important method used when studying the chemistry of Carbon[5]. Fourier Transform Infrared (FTIR) produces markedly superior spectra and can provide more precise information concerning the oxidation of carbons and the formation of carbon-oxygen surface groups. This technique can also allow measurements of lower concentrations of surface functional groups.

Sudan is one of the countries producing a wide variety of agricultural products. Its production of fruits tolls up to 48000 metric tons and oilseeds is about 60000 metric tons[14]. It will be more beneficial if the agricultural waste can be re-utilized for production of activated carbon especially there is an increased demand for the activated carbon world wide.

The main objective of this study was to prepare activated carbon from two agricultural waste product – namely Corn maize and Doum. Also to study its chemical and physical properties. The efficacy of the prepared activated carbon as adecoloring agent and its antibacterial efficacy will be investigated

MATERIALS AND METHODS

Preparation of activated carbon

Two agricultural products Doum fruit(*Hyphaenethebaica*) and corn maize(*Zea mays L.ssp*)were obtained from the local markets in Khartoum State –Sudan and were used for preparation of the activated carbon. Samples were grounded to a powder using an electric grinder after cleaning and removal of foreign materials.

1-Carbonization:

Two modified methods are used for carbonization and activation

Carbonization: The carbonization of the materials was done at 350^{o}C for two hours and allowed to cool at room temperature according to the method of [15].

Activation: The method of[16] was used. After sample preparation, 100 grams of the each sample was mixed with 250 ml of KOH . The samples were impregnated in muffle furnace at 600 °C for 1 hour.Washing of prepared sample was carried to clean the base content of the prepared AC. The washing process was continued until pH 7 was attained. The samples were then dried in oven at 105 °C to remove any moisture content .

2-Determination of Physical and chemical properties: these included pH, moisture , ash content, Volatile matter and was carried out according to the method by CEFIC.[17]

3-Determination of Carbon content and porosity

Carbon content was determined according to the method mentioned by [18]. Porosity was determined using the following expressions[15]

Porosity = Vv/Vt

Where Vv = volume of void, Vt = total volume

4-FTIR analyzer:

The samples were grinded and milledwith100mgKBr(disc) to form a fine powder. This powder was then compressed into a thin pellet under 7 tons weight for5 minutes. The sample was then analyzed using Fourier Transform Infrared (Shimadzu8300) spectrometer and the spectrum was recorded in a spectralrangeof400-4000cm^{-1}.

5-Decoloring efficacy:
The efficacy of the activated carbon for dye removal was studied using methylene blue dye. One gram of the activated carbon was added to 25ml of the dye. Samples were drawn at different time interval (24 hours) and after measuring the optical density [6]the following equation was used to calculate the decolorizing efficacy:

Decolorizing efficacy DE (%) = $(A0-A1)/A0 \times 100$ %

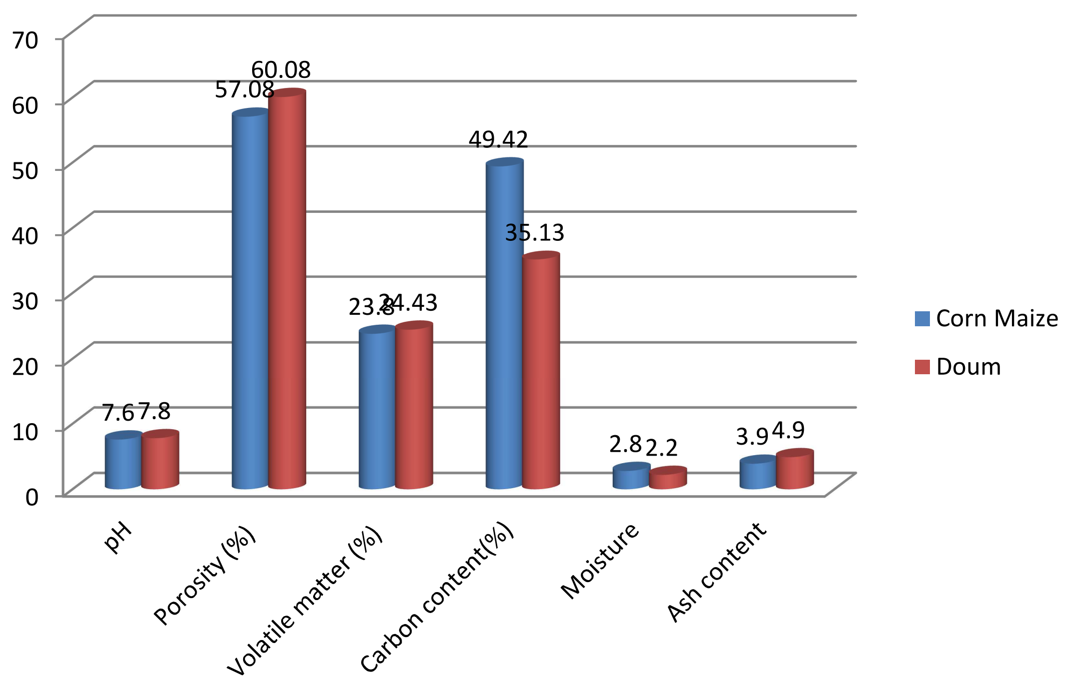
The absorbance of original liquor was taken as A0 and that of dye was taken as A1.

6- Antibacterial activity : the antibacterial efficacy of activated carbon was tested using the disc assay method. Water samples were collected in sterile containers from local farms in Khartoum State. Water samples were first tested for bacterial contamination. In petri dishes containing Nutrient agar , a 6mm diameter holes were made after water samples were spread using a sterile swab. About 25mg of activated carbon was placed in the hole and the plates were incubated for 48 hours at 37^{o}C. After the incubation period, the antibacterial activity of the activated carbon was determined through measuring the diameter of inhibition zone[19].

RESULTS AND DISCUSSION

Fig.(1) shows the results of proximate analysis of activated carbon prepared from two different agricultural waste materials Corn maize and Doum fruit using chemical activation with potassium hydroxide (KOH).

Fig 1 Physical properties of activated carbon prepared from Corn maize and doum

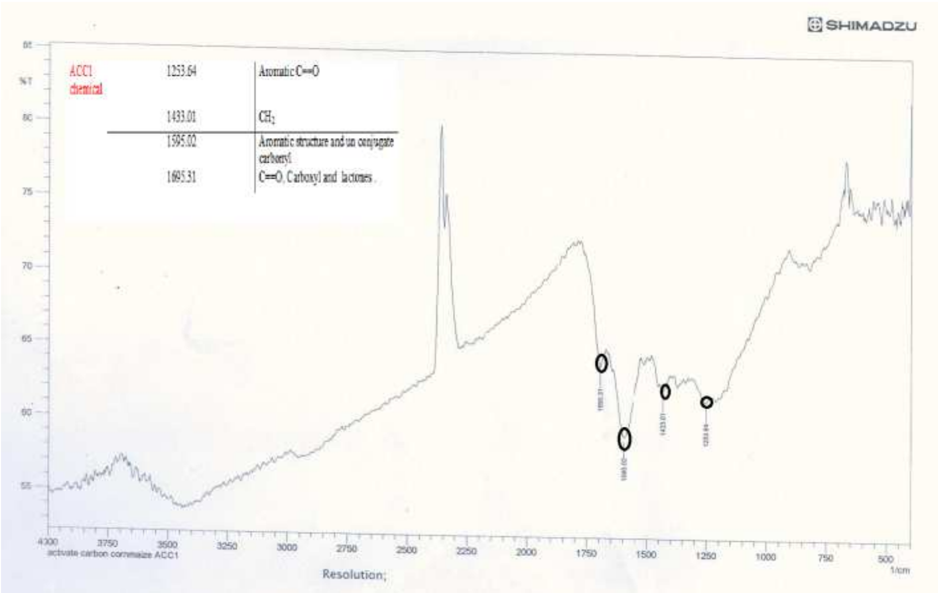


The proximate analysis included measurement of pH, porosity , volatile matter , carbon content , moisture and ash content.

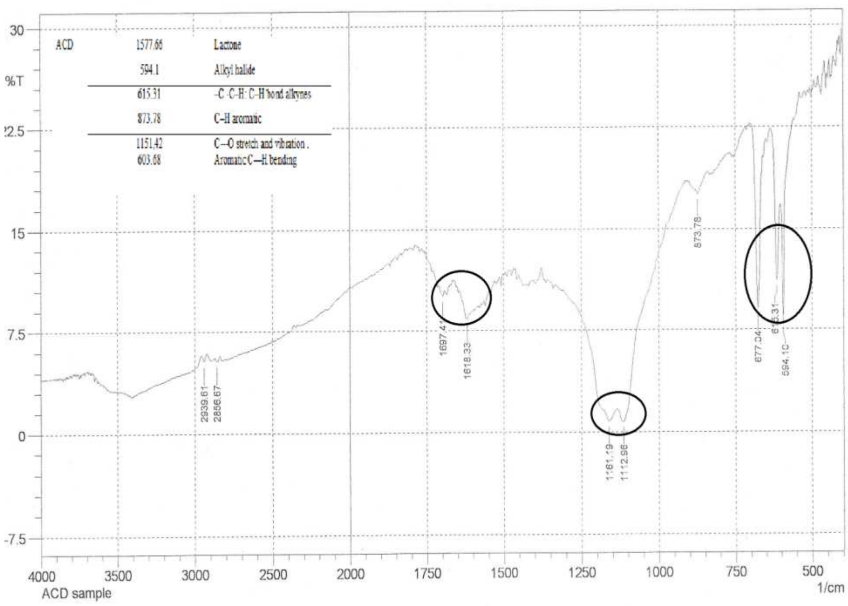
The carbon content of the samples were in the range from 35.00- 49. %. Corn maize samples had higher carbon content (49.42%) compared to sample doum which had carbon content of 35.13%, The results showed that the volatile matter of corn maize samples was lower (23.8%) than that obtained for doum (24.43%) .

The porosity percentage of the sample corn maize prepared by chemical activation of KOH was of 57.08% while a higher porose size was obtained in doum sample (60.08%). Analysis of samples indicated higher ash content of sample doum (4.9%). The advantage of using chemical activation method is the high yield of carbon and therefore high surface area of the activated carbon which leads to good adsorption. The result is similar to that reported previously by[20],[21]. Statistical analysis shows significance difference ($p \leq 0.05$) for carbon content determination between samples.

IR spectroscopy results which is used for analysis of corn maize and doum samples are shown in Fig 2 and Fig 3 respectively.



Fig(2)Infrared spectroscopy for activated carbon prepared from corn maize



Fig(3)Infrared spectroscopy for activated carbon prepared from doum

This analysis indicated that the functional groups of lactone with the frequency 1577.66 cm^{-1} and C---O at 1151.42 cm^{-1} and aromatic C---H at 873 cm^{-1} were found in the doumsample . The main functional group in corn maize sample were quinone , carboxyl and aromatic C--H Phenol , lactone ,C---O and aliphatic CH_2corn maize sample has functional groups of carboxyl and lactone , aromatic C=O at 1695.31 cm^{-1}.Functional groupsare indicators to other important parameters that influence and determine the adsorption of metal ions from aqueous solutions are the carbon-oxygen functional groups present on the carbon surface. Although all of these surface groups influence the adsorption of inorganics from aqueous phase, the carbon oxygen surface groups are the most influencing and important. This result is similar to that mention by [22],[23].

However, Detection of inorganic and organic elements on activate carbon also affect adsorption mechanism through different ways .The adsorption of organic and inorganic compounds from their aqueous solutions has also been found to be influenced by the presence of carbon-oxygen surface groups[23].Traces of inorganic elements may have a role in the ions interaction and ion exchange during adsorption mechanism. Some pervious study mention that The variation in elemental concentrations in both samples, which may attributed to adsorption study. Transition metals are often used to catalyze redox reactions [24].Variation of presences of inorganic elements and organic groups on activate carbon prepared from waste may be due to the chemical composition of the samples.

Decoloring activity

When the decoloring activity was studied , activated carbon prepared from corn maize samples had a higher percentage of dye removal when compared to doum (Fig. 4 and Fig.5). Previous studies showed that activated carbon prepared from various material such as bagasse had the ability to decolorize melanoidin (Melanoidin, is nitrogenous brown polymer present in molasses' wastewater[24].Also Activated carbons prepared from other agricultural solid wastes namely silk cotton hull, coconut tree sawdust, sago waste, maize cob and banana pith showed their ability to eliminate heavy metals and dyes from aqueous solution[24],[26]. During dye adsorption, the dye molecules has to pass from boundary layer film onto carbon surface and then diffuse into the porous structure of the activated carbon[27].

Fig. 4 Declouring efficency of corn maize doum and corn versus time

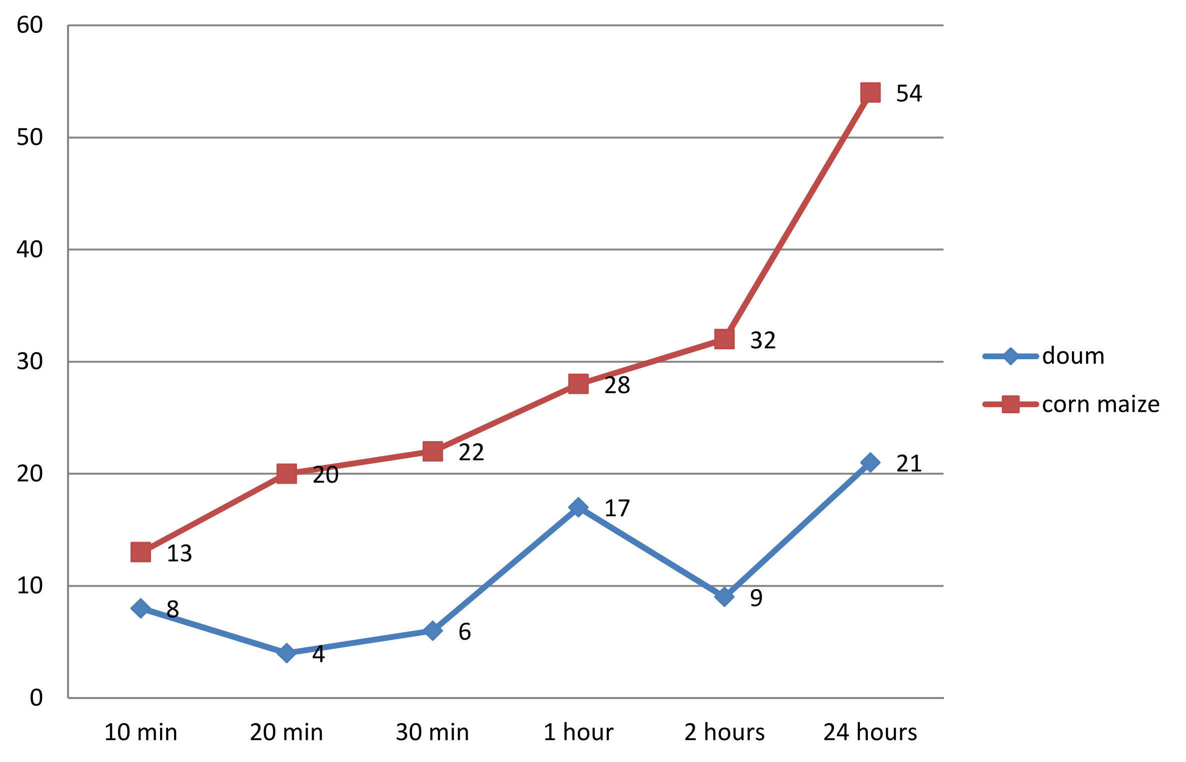
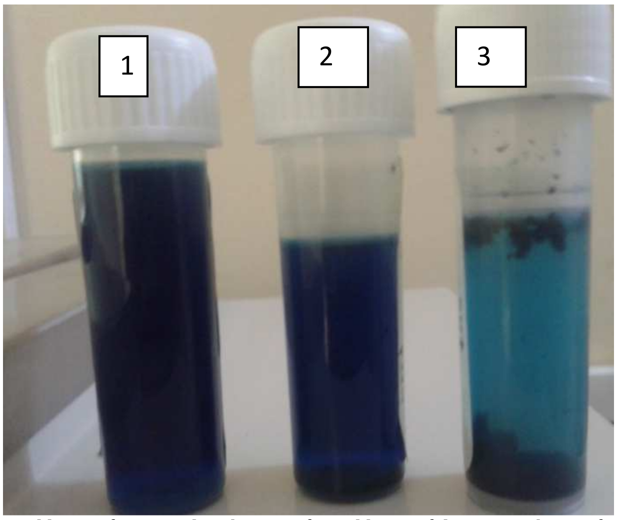


Fig 5.Decoloring activity of Activated carbon after six days

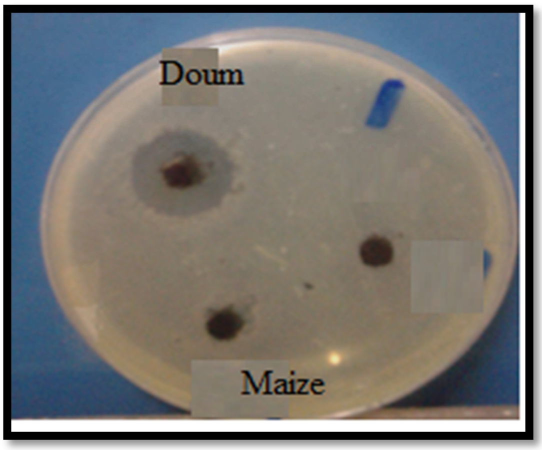


1- Methylene bluedye before addition of activated carbon, 2-After addition of doum samples3- After addition of maize samples

Antibacterial activity

The main bacteria isolated from water samples that were collected from local farms was *E.Coli*. Activated carbon from doum samples showed a better inhibitory effect than cornmaize samples. An inhibition zone in the range of 2.1 cm -4.2 cm was observed with doum samples (Fig.6) . Regarding the corn maize, no inhibition of growth of bacteria was observed

Fig 6 Antibacterial activity of Doum and Corn maize



Several studies showed that activated carbon has the antibacterial activity against bacteria like *Escherichia coli* and *Pseudomonas aeruginosa* from fresh and potable water systems [13],[7]particles through strong Lifshitz vander Waals forces[28] despite electrostatic repulsion between negatively charged microorganisms and carbon surfaces. The results of the study carried by[29]showed antimicrobial capabilities of activated carbon composite - in which magnetite and silver- were used towards bacteria and on *Pseudomonas koreensis* and *Bacillus mycoides* cultures isolated from river water. Potable water systems are considered low in ionic strength so electrostatic interactions can offer the possibility of enhancing the efficacy of activated carbon to remove microorganisms from water by positive charge modification of the carbon surfaces. Once there is a charge reversal, the electrostatic attraction between negatively charged microbial cell surfaces and positively modified carbon particles will be strong [30],[31].

The main difference between different types of activated carbons is the number of attractive sites revealed upon traversing of a carbon particle through the outer bacterial surface layer[32].Smaller inhibition zone seen with some materials can be attributed to the texture and size of the granules since finer material (such as sand) can be more efficient in bacterial removal than the coarse material[33].

CONCLUSION

The use of waste agricultural waste can be advantageous when it is used for preparation of activated carbon.

Physical and chemical properties of activated carbon prepared from Corn maize and doum have a good activity for removal of dyes and as antibacterial substance Other applications for the use activated carbon would be beneficial such as removal of pesticides and insecticides.

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