

Characterization of Activated Carbon prepared from *Albizia lebbek* by Physical Activation

K. Riaz Ahamed, T. Chandrasekaran, A. Arun Kumar

PG and Research Department of Chemistry, Jamal Mohamed College (Autonomous)
Tiruchirappalli-620020.Tamil Nadu, India.

Abstract: The paper presents results of a study on obtaining activated carbon from *Albizia lebbek* and on its use as adsorbent. The plant was abundantly found in tropical area. The effects of activation temperature of the activated carbon were studied. It was found that significant weight losses occurred during the activation process due to a continual release of volatile matter and carbon burn-off through weak carbon $-CO_2$ oxidation, resulting in an increase of solid density and a decrease of apparent density. Hence, the activated carbons prepared from the stem of *Albizia lebbek* possessed well-developed porosities, which were verified by Scanning Electron Microscopy (SEM). The nature of the compound can be identified by X-ray diffraction (XRD). The development of micro porosity of the *Albizia lebbek* carbon would leads to potential applications for the removal of metal ions. This could be elucidated by the surface functional groups of the *Albizia lebbek* carbon, as detected by Fourier Transform Infrared Spectroscopy (FTIR).

Keywords: Activated carbon, SEM, XRD, FT-IR.

I. INTRODUCTION

Activated carbon used as an adsorbent in an adsorption techniques. There are various technologies have been developed over the years to remove toxic metals from water including electrochemical[1], reverse osmosis [2], ion exchange [3], solvent extraction [4], adsorption [5,6] and photochemical methods [7]. Adsorptions are one of the more popular methods for the removal of heavy metals from the wastewater. Many adsorbents are used for the sorption of toxic metals such as magnetic chitosan nanoparticle, industrial wastes, pre-treated arca shell biomass, coir pith, zeolite and ligand supported adsorbents [8]. However, the selection of the wastewater treatment methods is based on the concentration of waste contaminants and the cost of treatment. All the materials present to have good sorption capacity, but they are not able to reduce the heavy metal concentration below the discharge limits or near to zero established in environment statutory. The widespread industrial use of low-cost adsorbents for wastewater treatment is strongly recommended and investigated due to their technical feasibility, engineering applicability and cost effectiveness. Therefore, many scientists tried hard to find efficient and low-cost materials for selective detection and recovery of metals ions [9-11]. Activated carbon found to be cheap and eco-friendly adsorbents.

It is a black carbonaceous material and amorphous in nature. According to Bansal[12], the effectiveness of activated carbon as an adsorbent is attributed to its unique properties, including large surface area, a high degree of surface reactivity, universal adsorption effect and favorable pore size. These unique pore structures play an important role in many different liquid and gas phase applications because of their adsorptive capacity [13]. The structural properties of activated carbon are very important to its effectiveness as an adsorbent, though activated carbon's structure is not fully understood and is difficult to explain. In general, activated carbon is sometimes described as having a 'crumpled' layered surface, in which flat sheets are broken and curved back upon themselves. This unique structure creates activated carbon's very large surface area. It can be more properly visualized with the attached images, which provide both electron microscope photos and conceptual diagrams of the surface structure. The complex internal surface area is usually divided

into three components. Channels and pores with diameters less than 2 nm are commonly known as micropores. These micropores generally contain the largest portion of the carbon's surface area. On the other hand, pores with diameters between 2 and 50 nm are known as mesopores, and pores with diameters greater than 50 nm are defined as macropores. Active carbon can be prepared either by physical activation or chemical activation. Physical activation takes place from 600°C to 1200°C without an activating agent. Chemical activation takes place in presence of dehydrating agent like Phosphoric acid, Potassium hydroxide, Zinc chloride, Sulphuric acid, etc., presence of an activating agent it lowers the activation temperature and it increase a surface area of the carbon. Various carbonaceous materials used for the removal of heavy metal pollutants are rubber seed coat carbon (*Hevea brasiliensis*) myrobalon waste carbon (*Terminalia bellirica*), cashew nut sheath carbon (*Anacardium occidentale L.*), palm tree flower carbon (*Borassus flabellifer L.*), pongam seed coat (*Pongamia pinnata L.*) [14], eucalyptus stem bark carbon (*Eucalyptus teriticornis smith*) [15], date palm arabianut carbon [16], resak wood carbon (*Vatica hullettii*) [17], More recently interests have been shown in the preparation of activated carbon using agricultural by- products as precursor materials. The tree *Albizia lebbek* is an evergreen tropical tree. A tropical tree also grows easily in sub-tropical climates and grows largely all over India. The tree is also drought resistant and is grown in many waste lands and available in plenty everywhere. The stem of the tree does not possess any much importance to an environment.

The present work deals with the physically activated high temperature *Albizia lebbek* carbon of 53 μ mesh particle size. Surface morphology of the carbon particles were carried out by using scanning electron microscope (SEM) to analyze the pores on the surface of the carbon particles where the adsorption takes place and Fourier transform infrared (FT-IR) spectroscopic studies were done to find the groups responsible for adsorption. The nature of the activated carbon can be found using X-Ray diffraction (XRD). High temperature for *Albizia lebbek* carbon was compared with commercial activated carbon (CAC).

II. Materials and Methods

A. Sample collection and preparation:

The stem of the *Albizia lebbek* waste was collected from agricultural land. The stems were washed thoroughly with water, cut into smaller bits rinsed with distilled water, air-dried in shallow place and later oven dried.

B. Activation of the carbon:

A dried sample of *Albizia lebbek* placed in a muffle furnace and heated at 800°C for two hours. This was allowed to cool and washed with distilled water to a pH of 7, oven dried at 105°C for four hours and grounded. It was sieved with a 53 μ mesh to obtain a fine powdered activated carbon and it was kept in an air tight container and used for the various experiments.

C. Characterization of Activated carbon:

The carbon prepared from the plant was subjected to characterization such as surface area, bulk density, moisture content, ash content, matter soluble in water, matter soluble in acid, pH, iron content were tested to access the suitability of these carbon for water and waste water treatment. The results are compared with commercially available activated carbon and are presented.

In order to study the structure sight of the activated carbon, Scanning Electron Microscopy (SEM) was employed to visualize morphology of an activated carbon. XRD is also used for the study of nature of activated carbon. The FT-IR spectra (KBr) were recorded on a Shimadzu (4000-400 cm^{-1}) spectrometer.

III. Result and discussion

A. Characterization of the adsorbent:

Activated carbon is widely used as an adsorbent due to its high adsorption capacity, high surface area, micro porous structure and high degree of surface respectively. The wide usefulness of carbon is a result of its specific surface

area, high chemical and mechanical stability. The chemical nature and pore structure usually determine the sorption activity. The physico-chemical properties of the chosen adsorbent and commercial activated carbon were compared and listed in table-1.

S.No.	PARAMETERS	CAC	ALC
1	Bulk density (g/cc)	0.68	0.44
2	Moisture content (%)	12.57	2.15
3	Ash content (%)	2.91	9.3
4	Matter soluble in Water (%)	1.55	0.81
5	Matter soluble in Acid (%)	4.58	4.01
6	pH	9.2	8.9
7	Surface area (m ² /g)	296	418
8	Iron content (%)	-	0.08

CAC – Commercial activated carbon, ALC – *Albizia Lebbeck* activated carbon.

Table 1. Characterization of adsorbent.

B. Fourier Transform Infrared Spectra (FT-IR):

Figure-1 shows the functional groups and surface properties of the adsorbent by FTIR spectra. The spectra of the adsorbent were measured in the range of 4000-400cm⁻¹ wave number. The FT-IR spectrum reveals the complex nature of the adsorbents as evidenced by the presence of a large number of peaks. The peak obtained at 3458.52 cm⁻¹ indicates the existence of free and intermolecular bonded hydroxyl groups. Peaks around 1604.84 cm⁻¹ corresponds to the C=O stretching that may be attributed to the lignin aromatic groups. The peaks at 1449.57 cm⁻¹ indicates C=C groups present in carbon. The peaks around 875.72 cm⁻¹ shows the appearance of C=H group present in surface of carbon.

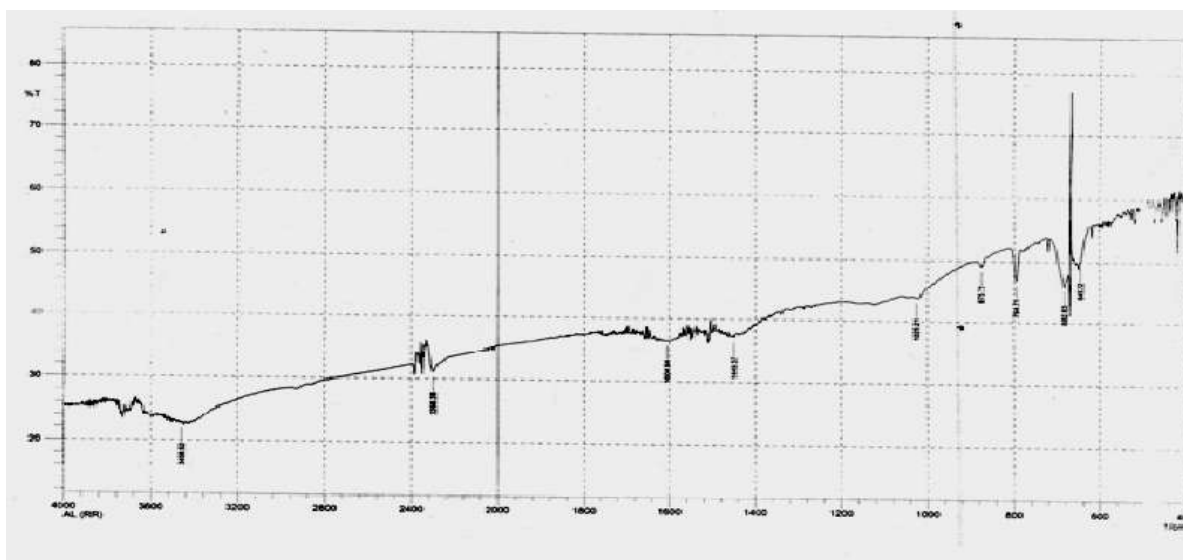


Fig. 1. FT-IR spectrum for adsorbent.

C. Scanning Electron Microscopy (SEM).

The scanning electron micrographs enable the direct observation of the surface microstructures of the adsorbents. Figure-2 illustrates the SEM of adsorbent at 1000X and 3000X which shows irregular groove and ridges in fibrous network that is considered helpful for the accessibility of metal ions to the adsorbent surface.

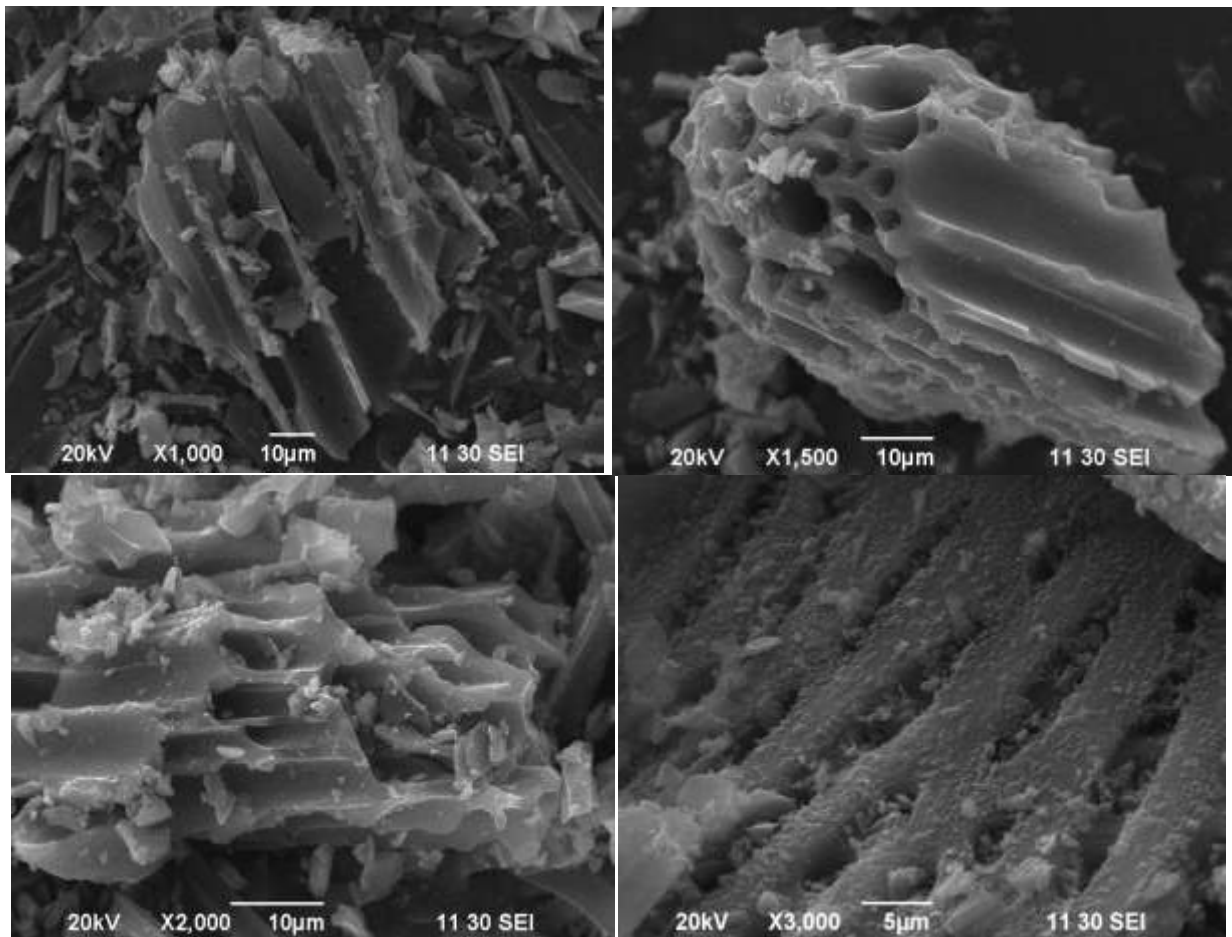


Fig. 2. Shows SEM micrographs at two different magnifications.

D. X-ray diffraction studies.

Figure-3 illustrates the XRD pattern of the activated carbon prepared from *Albizia lebbek* with an activated temperature of 800°C. The activated carbon exhibited peaks at around $2\theta = 27^\circ$ which correspond to the peak of graphite [18]. At the same time, it exhibits noise of the powder XRD signals. This reveals a predominantly amorphous structure of carbon. In this result, it can be explained that the pyrolytic reaction of organic compounds consists of the breaking of chemical bonds with temperature and condensing further into active compounds. These compounds form typical graphitic layers and stacks of planes during carbonization [19]. The appearance of a broad peak at $2\theta = 27^\circ$ indicated that the activated charcoal was amorphous in nature.

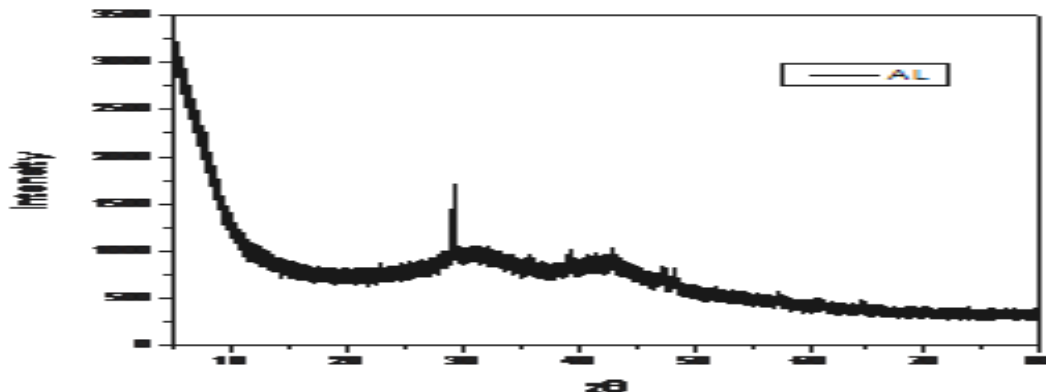


Fig. 3. Shows the XRD pattern of Activated carbon.

E. Comparison of prepared activated carbon with commercial activated carbon

The characterizations of prepared activated carbon from plant *Albizia Lebbeck* has been compared with commercial activated carbon and the values are shown in table-1. From this table we can conclude that this activated carbon has a higher surface area than the commercial activated carbon. So that, the prepared activated carbon can adsorb more amount of metal ions from water and it is used for the remove of acidic ions from the waste water treatment due to the presence of basic nature of the activated carbon.

IV. Conclusion

As the carbonization temperature increases, the resulting *Albizia lebbeck* charcoal is better in clearly structure and ordering. At temperature 800°C *Albizia lebbeck* charcoal has a good influence on the carbon with generation of moderately developed charcoal production and shows characteristic surface area in the activated carbon. Thus an activated carbon prepared in our laboratory from *Albizia lebbeck* used as an alternative for commercial activated carbon and used for removal of impurities from water and wastewater. Based on surface area the activated carbon prepared are comparable with commercially available carbon. From this it have been concluded that activated carbon prepared from *Albizia lebbeck* can be used as a new, low-cost, easily available and ecofriendly adsorbent or catalyst.

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References

- [1] Kushwaha JP, Srivastava VC, Mall ID, (2010) "Organics removal from dairy wastewater by electrochemical treatment and residue disposal Separation and Purification Technology", 76:198-205.
- [2] Perez-Gonzalez A, Urriaga AM., Ibanez R, Ortiz I, (2012) "State of the art and review on the treatment technologies of water reverse osmosis concentrates", Water Research, 46:267-283.
- [3] El-Gohary F, Tawfik A, Mahmoud U, (2010) "Comparative study between chemical coagulation/precipitation (C/P) versus coagulation/dissolved air flotation (C/DAF) for pre-treatment of personal care products (PCPs) wastewater", Desalination, 252:106-112.
- [4] Dabrowski A, Hubicki Z, Podkościelny P, Robens E., (2004) "Selective removal of the heavy metal ions from waters and industrial wastewaters by ion-exchange method", Chemosphere, 56:91-106.
- [5] Manis Kumar Jha, Kumar V, Jeong J, Jae-chun Lee, (2012) Review on solvent extraction of cadmium from various solutions, Hydrometallurgy, 111-112:1-9.
- [6] Mohan D, Rajput S., Singh VK, Steele PH, Pittman CU, (2011) "Modeling and evaluation of chromium remediation from water using low cost bio-char, a green adsorbent", Journal of Hazardous Materials, 188:319-333.
- [7] Yeo J, Kim Dh, Bokare AD, Choi W, (2012) "Photochemical removal of hexavalent chromium through iodide oxidation under 254 nm irradiation Separation and Purification Technology", 91:18-22.
- [8] Smiciklas I, Dimovic S, Plecas I, Mitric M, (2006). "Removal of Co²⁺ from aqueous solutions by hydroxyapatite" Water Research, 40:2267-2274.
- [9] Pan X, Wang J, Zhang D, (2009). "Sorption of cobalt to bone char: kinetics, competitive sorption and mechanism" Desalination, 249:609-614.
- [10] Smiciklas I, Dimovic S, Plecas I, Mitric M, (2009). "Comparative study of differently treated animal bones for Co²⁺ removal" Journal of Hazardous Materials, 16:279-287.
- [11] Wang Q, Li J, Chen C, Ren X, Hu J, Wang X, (2011). "Removal of cobalt from aqueous solution by magnetic multiwalled carbon nanotube/iron oxide composites" Chemical Engineering Journal, 174:126-133.
- [12] Bansal, Ch R, Goyal M, (2005) "Activated Carbon Adsorption" Taylor & Francis, Boca Raton .

- [13] Tsai WT, Chang CY, Wang SY, Chang CF, Chien SF, Sun HF,(2001) Bioresource Technol., 78:203-208.
- [14] S. Rengaraj, Banumathi Arabindoo, V. Murugesan. (1999). "Preparation and Characterization of activated carbon from agricultural wastes" Indian J. Chem. Technol., 6:1-4.
- [15] Sreenivasalu A, Sundaram EV, Komal Reddy M, (1999). "Phosphate adsorption studies using carbon prepared from stem bark of Eucalyptus teriticornis Smith" Indian J. Chem. Technol., 6:256-262.
- [16] Balasubramanian KP, Kumar PE, Kulandaivelu AR, (2002). "Studies on chloride removal from sugarcane effluent by activated carbon derived from Date Palm Arabia Nut" oriental J. Chem., 18(1):169-170.
- [17] Anuar K, Collin Joseph G, Faujan Ahamed BH, Zulkarnain Z, Zobir Hussain M, Halim Abdullah A. (2002). "Preparation and characterization of activated carbon from Resak wood (vatika Hullettii). Surface area and porosity studies" Oriental J. Chem., 18(1):43-46.
- [18] Gupta AK, Ganeshan K, Sekhar K. (2006). "Adsorptive removal of water poisons from contaminated water by adsorbents" J. Haz. Mat., 137:396-400.
- [19] Lua AC, Yang T. (2004). "Effect of activated temperature on the textural and chemical properties of potassium hydroxide activated carbon prepared from pistachio-nut shell" J. Colloid. Interface. Sci., 274:594-601.