Research Article

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Preparation and Characterization of Activated Carbon from *Polyathia longifolia* Seed Waste through various Activation Processes

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ABSTRACT

Activated carbon prepared from *Polyalthia longifolia* seeds by various chemical processes have shown excellent improvement in the surface characteristics. Surface morphology plays a significant role in the adsorption properties along with surface functional groups, activated carbon microspores, mesopores and macrospores. The volume of these pores varies depending upon the activating agents used during various processes. SEM was used to examine the morphology of the resulting sample, and infrared spectroscopy was used to investigate the surface functional group. Physico-chemical characteristics such as bulk density, moisture content, ash content, matter soluble in water, soluble in acid, pH, iodine number, conductivity, porosity, yield percentage and surface area were measured to determine the carbon's suitability as an adsorbent. The findings have shown that activated carbon made with *Polyalthia longifolia* by H_2So_4 impregnation followed by activation at 110 °C yielded activated carbon with the largest surface area and the most developed micro-, meso- and macro-porosities.

Keywords: *Polyalthia longifolia*; Activated carbon; Carbonization; SEM; XRD; IR.

1. INTRODUCTION

High-surface-area activated carbons are exceptionally flexible adsorbents with substantial industrial implications (Mahmut and Ayhan, 2005). These are used in a variety of applications involving the removal of species from the liquid or gas phase by adsorption. A variety of precursor materials, including wood, agricultural wastes and coal, can be used to make activated carbons (HO *et al.* 1995). Carbons are activated by a variety of physical and chemical processes. For the past few decades, focus has been moved towards adsorption technology to create carbon with a high adsorption capacity for a specific purpose. Adsorption is a frequently used technique for removing contaminants from wastewater. The process of activated carbon adsorption is cost-effective. The manufacture of activated carbon from *Polyalthiya longifoliya* tree seed debris has been the subject of recent research. A variety of low-cost alternatives, such as sago waste, have been offered (Ivan and Branka, 2005). Prepared *Polyalthiya longifoliya* seed (PALS) waste activated carbon were characterized by SEM, XRD and IR. They were tested for antimicrobial activity.

2. PREPARATION OF ACTIVATED CARBON

Activated carbon was prepared from Asoka tree seed waste, which was locally procured at Erode Arts College, Erode, Tamilnadu, India. The material was dried in sunlight, impregnated with concentrated H_2SO_4 and carbonized at 110 °C. The impregnation ratio of acid volume to weight of plant material 1:1 (w/v) was employed. Before utilization, the carbon was washed with distilled water and then dried in a hot air oven at 100 ± 5 °C. Finally, it was ground and sieved.

3. ACTIVTED CARBON PREPARED FROM PALS WASTE BY DIFFERENT ACTIVATION PROCESS

Table 1. Activated carbon prepared from PALS waste by different activation process.

Sample	Treatment process
BAC1	H_2SO_4 Process +Thermal Activation under N_2 flow
BAC2	H_3PO_4 Process +Thermal Activation under N_2 flow
BAC3	Na_2CO_3 Process +Thermal Activation under N_2 flow
BAC4	$CaCO_3$ Process +Thermal Activation under N_2 flow
BAC5	Na_2SO_4 Process +Thermal Activation under N_2 flow

4. CHARACTERIZATION STUDIES OF ACTIVATED CARBON

4.1 SEM Analysis

Scanning Electron Microscopy (SEM) has been the primary tool for characterizing the surface morphology and fundamental physical properties of adsorbents' surface. It was useful for determining the particle shape, porosity and appropriate size distribution of the adsorbent. The SEM micrographs of raw PALS, shown in Fig. 1, 2 and 3, have clearly revealed that PALS has considerable numbers of pores; this indicates a good possibility for dyes to be trapped and adsorbed into these pores. The distinguished dark spots seen in the SEM images can be taken as a sign for effective adsorption of dye molecules in the cavities and pores of the adsorbent.

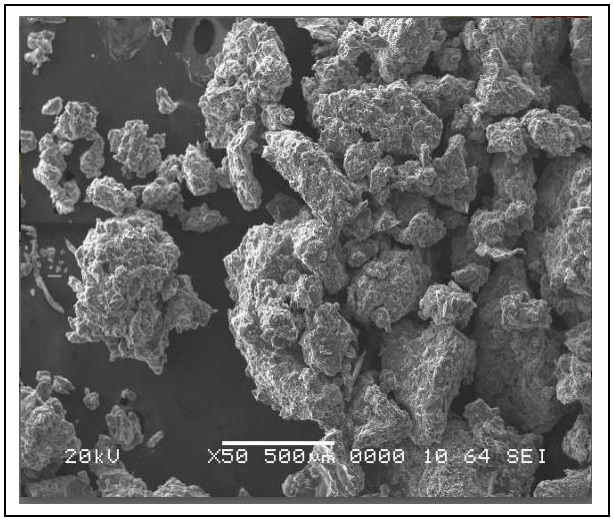

Fig. 1: SEM image of *Polyalthiya longifoliya* carbon (x 50)

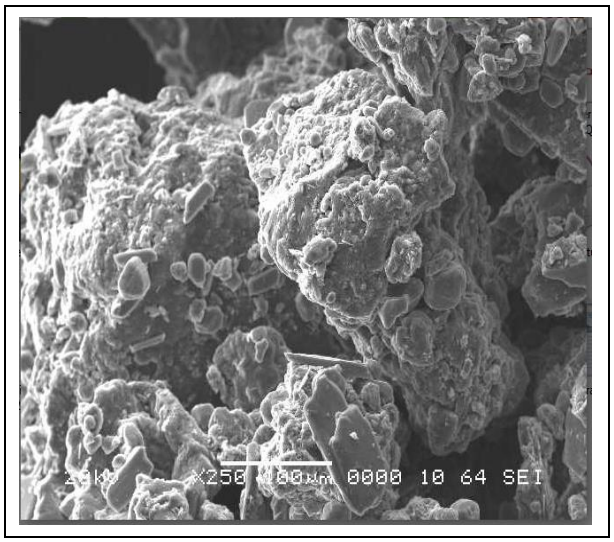

Fig. 2: SEM image of *Polyalthiya longifoliya* carbon (x 250)

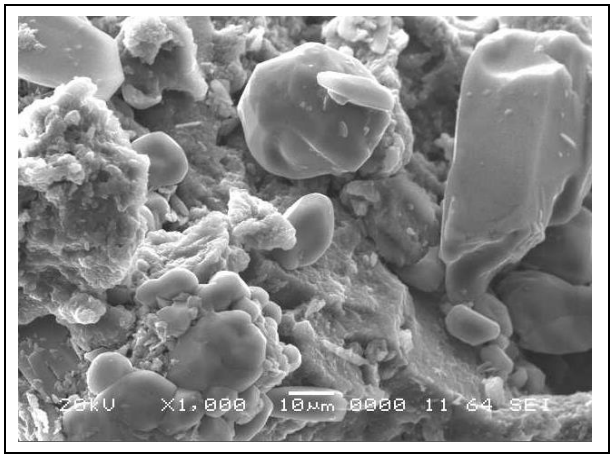

Fig. 3: SEM for *Polyalthiya longifoliya* carbon (x 1000)

5. pH AND CONDUCTIVITY

1 g of the carbon in 200 ml of distilled water was equilibrated by agitating at 165 rpm for 1 h and filtered using Whatman filter paper. pH and conductivity of supernatant solution were checked by using pH meter and conductivity meter, respectively.

5.1 Moisture Content

1 g of carbon was put in a China dish and heated for 1 h in an oven at 110 °C and then cooled in a desiccator before being weighed. At 30-minute intervals, the heating, chilling and weighing were repeated until the difference between the two subsequent weights was less than 1 mg. The moisture content was determined from the weight loss.

$$\text{Moisture content (\%) by mass} = \frac{M-X}{M} \times 100$$

where,

M - Mass of the material taken for test (g)
X - Mass of the material after drying (g).

Moisture content carbon = 42.89%

5.2 Ash Content

About 1 g of carbon was weighed accurately in a silica crucible and placed in an electric furnace at 180 °C about 1 hr. The crucible was removed from the electric furnace after heating, and the crucible was cooled in a desiccator and then weighed. The process of heating and cooling was repeated until the difference between two consecutive weight was less than 1 mg.

$$\text{Ash (on dry basis) \% by mass} = \frac{M_1}{M_2-X} \times 100$$

where,

M_1 - mass of the ash (g)
M_2 - Mass of the material taken for test (g)
X – percentage of moisture content present in the material taken for test.

ASH content = 36.86%

5.3 Matter Soluble in Water

5 g of carbon material with a known moisture content was accurately weighed and added to a 1-liter beaker. 300 ml of distilled water was added and brought to a boiling state while continually stirring. The churning was continued for another 5 minutes after the heat was turned off. The material was then allowed to settle. An asbestos-matted crucible was used to filter the supernatant. The method was done three times with the residue in the beaker using 300 ml of water each time; the combined liquid was concentrated to less than 100 ml over a water bath, chilled and made up to the 100 ml mark in a volumetric flask. 50 ml of the concentrate was transferred to a China dish and almost fully evaporated on a boiling water bath before being dried in an electric oven at 100 ± 5 °C, chilled in a desiccator and weighed. Every 30 minutes, the drying and weighing process was repeated until the difference between the two consecutive weights was less than 5 g.

$$\text{Matter soluble in water (\%)} = \frac{M_1}{M_2\text{-}X} \times 100$$

M_1 - Mass of the residue (g)

M_2 - Mass of the material taken for test (g)

X - Percent of moisture present in the material

6. METHODS

6.1 Antimicrobial Activity of *Polyalthia longifoliya*

The multidrug-resistant pathogens *Escherichia coli* and *Staphylococcus aureus* were procured from KMCH Laboratories, KMCH Hospitals, Coimbatore, Tamilnadu, India. The optimal 24-hour broth cultures of *Escherichia coli* and *Staphylococcus aureus* were used for antimicrobial activity. The circularly cut filter paper soaked in the mixture of powdered *Polyalthia longifolia*, which are soaked in concentrated H_2SO_4 at various concentrations (0.1 – 0.5%) was added to the plates and incubated at 37 °C for 24 h. The powdered *Polyalthia longifolia* samples that were found effective as an antimicrobial agent during the qualitative test were tested to determine the minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC) values for each strain. MIC was determined by the broth dilution method. About 100 µl of 10^5 CFU/ml of the test culture was inoculated in tubes with an equal volume of nutrient broth and powdered *Polyalthia longifolia* samples. The tubes were incubated aerobically at 37 °C for 24 h. Two control tubes were maintained for each strain (media control and organism control). The dilutions showing no turbidity were incubated further for 24 h at 37 °C. The lowest concentration that produced no visible turbidity after a total incubation period of 48 h was regarded as the final MIC. MBC value was determined by sub-culturing the test dilution [which showed no visible turbidity] onto freshly prepared nutrient agar media. The plates were incubated further for 24-48 h at 37 °C. The highest dilution that yielded no single bacterial colony on the nutrient agar plates was taken as MBC.

6.2 RESULTS AND OBSERVATION

The antimicrobial activity between the powdered *Polyalthia longifolia* was done. The powdered *Polyalthia longifolia* in 20 µl produced by soaking it in concentrated H_2SO_4 has shown the highest sensitivity against both *E. coli* and *Staphylococcus aureus*, whereas the powdered *Polyalthia longifolia* in 10 µl has shown the least amount of sensitivity against both multidrug-resistant microorganisms.

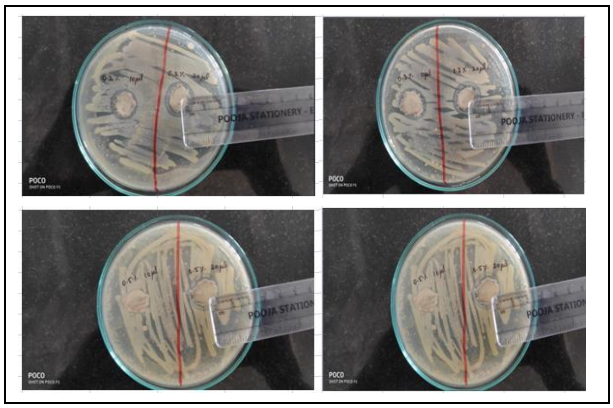

Fig 3: Antimicrobial studies of PALS

7. CONCLUSION

Polyalthia longifolia seed debris was used to make activated carbon with a substantial surface area. By treating prepared activated carbon with concentrated H_2SO_4, the difference in textual features associated with the activation process in the surface area was amplified. SEM studies revealed that the spherical-shaped nanoparticles were in the range of 55-8 nm.

Activated carbon prepared from the above process can be used for both organic and inorganic effluent removal. The synthesized *Polyalthia longifolia* seed extract in activated carbon proved outstanding antimicrobial activity and efficiency against multi-drug-resistant clinical isolates. It was well-established by the clear zone of inhibition against the antimicrobial activity.

The prepared activated carbon seed waste was tested against bacteria like *E. Coli and Staphylococcus aureus.*

The normal biological approach for antimicrobial activity using *Polyalthia longifolia* carbon was found to be an eco-friendly method, when compared to the physico-chemical synthesis.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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