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Research Article

CHARACTERIZATION OF CHEMICALLY MODIFIED AND MICROWAVE TREATED CARBON MATERIAL DEVELOPED FROM *FICUS BENGHALENSIS* LEAF

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ABSTRACT

A new bioadsorbent carbon material was developed by acid-base impregnation of carbonized *Ficus benghalensis* leaf followed by microwave treatment (MACFBL). Synthesized carbon material was characterized using proximate and ultimate analysis. The element analysis of prepared bioadsorbent of *Ficus benghalensis* leaf shows 39.74 % carbon, 1.09 % hydrogen and 0.55 % nitrogen. The surface morphology and the chemical composition of MACFBL was analysed by SEM and EDX, respectively. EDX results of acid-base impregnated bioadsorbent of *Ficus benghalensis* leaf have 46.83% of carbon by weight. The surface chemical nature of bioadsorbent and functional groups on the surface of the active carbon was studied by FT-IR and XRD. The Brunauer-Emmett-Teller (BET) surface area under nitrogen adsorption at -196°C of prepared adsorbent was found 109.41 m^2/g. The present research work shows that microwave assisted and acid-base impregnated bioadsorbent of *Ficus benghalensis* leaf could be employed as low cost bioadsorbent material in bioengineering process in the removal of toxic pollutants from waste water. The results of the characterization of MAFBL carbon material also exhibited ideal adsorbent properties.

Keywords: *Ficus benghalensis* leaf, Characterization, SEM, EDX, FTIR, XRD.

1. INTRODUCTION

A leaf is an organ of a vascular plant and is the primary parallel member of the stem [1]. The stem and leaves together form the shoot [2]. Leaves are on the whole alluded to as foliage, as in, as in 'autumn foliage'. A leaf is a thin, dorsiventrally smoothed organ, generally borne over the ground and concentrated for photosynthesis. Leaves can have a wide range of shapes, surfaces and sizes. The wide, flat leaves with complex venation of flowering plants are known as *megaphylls* and the type that bear them, the larger part, as wide leaved or megaphyllous plants [3].

Various works had published with the essential objective being the examination of the expulsion of different pollutants by utilizing leaf based adsorbent materials [4-28]. Leaf-based biomaterials are of low cost-effective value, so cheap and richly accessible, largely composed of elevated levels of water soluble antioxidants, inorganic salts, proteins, and poly-phenols, etc., which make them viable adsorbent for an extensive variety of due to the presence of functional groups such as carboxyl, hydroxyl, methoxy, phenols, etc., that takes an interest in binding with the pollutants [29-31].

Ficus benghalensis (*F. benghalensis*) is viewed as local to tropical Asia, from India through Thailand, Myanmar, southern China, and Malaysia. It is likewise developed and naturalized in numerous tropical regions of the world together with Australia, North America, western Africa, the West Indies, the Middle East, and several islands in the Pacific sea. *F. benghalensis* is a big, evergreen to a deciduous tree, up to 20 m tall, with large leafy crown and branches distribution up to 100 m or more with column-like prop roots and adornment trunks. There are in excess of 800 species and 2000 assortments of Ficus species, a large portion of which are local to the old world tropics. *Ficus benghalensis* (Moraceae, commonly known as Banyan tree or Vada or Vata tree in Ayurveda, is an exceptional medicinal tree and is viewed as consecrated in numerous places of India. Leaves of *Ficus benghalensis* are utilized in the treatment of dysentery, diarrhoea, piles, skin disorders, Rheumatism, hypoglycemia and furthermore to reinforce the immune system. The extracts of *F. benghalensis* restrain insulin's action from kidney and liver. A portion of these disorders are supposedly activated by cobalt ions. Its leaves contain elevated amounts of water soluble antioxidants, inorganic

salts, proteins, and poly-phenols (Flavonoids). These phenolic compounds have ketonic and hydroxyl groups, capable of binding to different pollutants [1, 2].

The objectives of this study was to contribute in the search for less expensive bioadsorbent by analyzing the bulk density, moisture content, volatile matter, ash content, pH, fixed carbon content, water and acid soluble matter by proximate analysis and elemental, BET surface, EDX, SEM, FTIR and XRD analysis.

2. MATERIAL AND METHOD

2.1. Material

All chemicals used in the present work were of analytical grade and these chemicals obtained from S-D Fine Chemicals Ltd or Merck India limited. All glasswares used in the study were delivered using Borosil glass. Double distilled water was used for all the experiments.

2.2. Preparation of Adsorbent

Ficus benghalensis leaf sample was collected from the neighborhood local area. It was washed with water to remove dust and other impurities. After air drying, it was ground using a home blender and sieved through 300 mesh size. The sample was washed with double distilled water and dried in an oven at 80 °C for 24 hours. The resulting dried *Ficus benghalensis* leaf powder was carbonized on muffle furnace for 5 hours at 500 °C. This carbonized leaf powder again activated in a domestic microwave (900MW) by one-minute intervals for 30 minutes. The microwave-assisted carbonized leaf powder was then impregnated with 0.5 N sodium hydroxide and 0.5 N sulphuric acid for 24 hours separately. The resultant carbon material was washed with double distilled water until a steady pH of the slurry was obtained. Finally the carbon material was dried at 110°C in a vacuum oven, grinded well and kept in airtight plastic containers for further use. The activated material produced from the leaves of *Ficus benghalensis* was referred to as microwave-assisted carbonized *Ficus benghalensis* leaf (MACFBL).

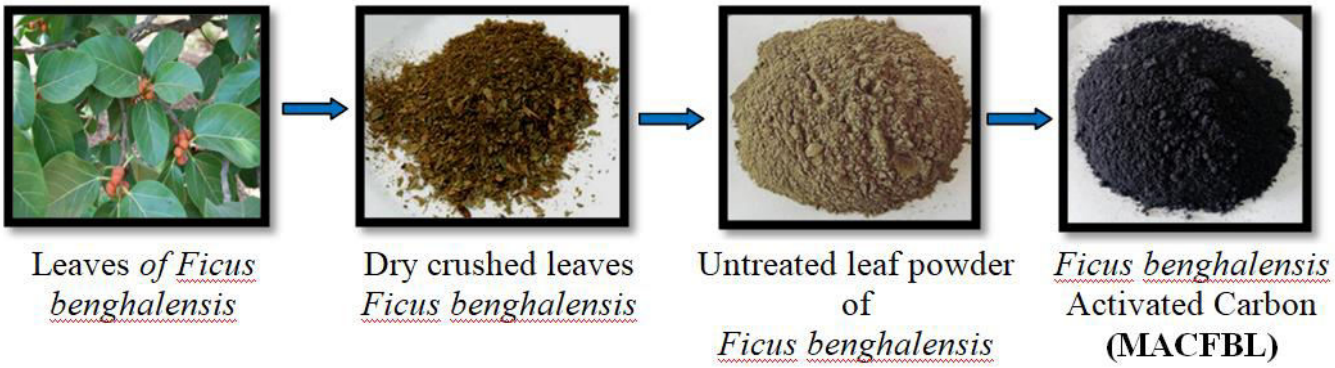

Fig. 1: Graphical representation of the development of carbon material (MAFBL)

2.3. Physico-chemical Characterization of adsorbent

2.3.1. Proximate analysis

Physico-chemical parameters such as pH, bulk density, moisture, ash, volatile matter, fixed carbon, water and acid soluble matter of MACAIB were analysed. The results of ultimate analysis obtained were as presented in Table 1. The pH for the activated MACAIB bioadsorbent was determined using the Elico pH meter, model LI-120, other parameters were analyzed by using standard test methods [32-34].

2.3.2. Ultimate analysis

The Brunauer-Emmett-Teller (BET) surface area pore characteristics were determined using computer-controlled nitrogen gas adsorption analyzer at -196 °C by Quanta Chrome Nova-1000 surface analyser instrument. The elements C, H, N and S were analyzed by using Elementar Vario EL III model (C-H-N Analyser). The examination and analysis of micro-structure morphology of MACAIB was recorded by using Scanning Electron Microscopy (SEM), (JEOL Model JSM- 6390LV). Electron dispersive X-ray (EDX) (JEOL JSM-7600F FEG-SEM model) was used for the element and chemical characterization of the activated MACAIB. The spectral analysis was done by Fourier Transform Infrared Spectrophotometer (FTIR) (Thermo Nicolet, Avatar 370) with KBr. FTIR spectra were recorded between 4000 and 400 cm^{-1}. The FTIR spectra give information about the characteristic functional

groups on the surface of activated MACAIB bio-adsorbent. The Structural integrity of the bio-adsorbent samples was checked by Powder X-ray diffraction (XRD) by Bruker AXS D8 Advance difractometer using Cu Kα radiation (λ=1.5406 Å).

3. RESULT AND DISCUSSION

3.1. Physico-chemical Characterization of adsorbent

The bulk density estimation of MACFBL carbon material showed the exceptionally branched and permeable carbons along with more void space [35]. Acid soluble matter content was found somewhat higher than the water soluble matter in the adsorbent material. The Moisture content of the MACFBL carbon is observed to be 4.28 % and has no impact on its adsorptive efficiency; however, it weakens the activated carbon which requires the utilization of extra weight of carbon during the treatment procedure [35]. The ash content and volatile matter ascribed to bring down inorganic content and higher fixed carbon. Higher assessment of fixed carbon indicated that the activated carbon is more proficient and stable. The high surface area of the adsorbent is measured to be the most appropriate for adsorption of fluoride in aqueous solution. The Brunauer-Emmett-Teller (BET) surface area, average pore diameter and total pore volume were found to be 109.41 (m^2/g), 90.72 (Å) and 0.248 (cc/g) show that MACFBL carbon material ought to be a wonderful adsorbent. The pH of MACFBL adsorbent has somewhat slightly basic in nature. From Table 1, the physico-chemical results obtained by characterization of MACFBL shows that the chemical activation and microwave treatment achieves the tremendous adsorbent carbon material required for fluoride adsorption.

3.2. Scanning electron microscope (SEM) study

Fig. 2 (a and b) shows the SEM micrographs of the MACFBL adsorbent material. SEM pictures of MACFBL demonstrate that the adsorbent material has a rough surface with nearly non-compact structure and a significant number of pore spaces. It is shown from the SEM images that the surface of MACFBL is observed to be not so irregular but rough in such an approach to follow the solute species onto the surface of the adsorbent. For this reason, the adsorptive characteristics of MACFBL are likely to be highly efficient. The bright spots demonstrate the existence of tiny holes on the crystalline structure of activated carbon [36, 37].

Table 1: Proximate and Ultimate analysis of MACFBL material

Proximate Analysis			Ultimate analysis		
S. N.	**Parameters**	**Values**	**S. N.**	**Parameters**	**Values**
1	Bulk density (gm/cm^3)	0.39	1	Carbon %	39.74
2	Moisture content %	4.28	2	Hydrogen %	1.09
3	Ash content %	14.73	3	Nitrogen %	0.55
4	Volatile matter content %	32.65	4	Sulphur %	00
5	Fixed carbon content %	48.34	5	Oxygen %	58.62
6	pH	7.63	6	Surface Area (m^2/g)	109.41
7	Water Soluble Matter (%)	1.24	7	Average Pore Diameter (A^O)	90.72
8	Acid soluble matter (%)	3.73	8	Total Pore Volume (cc/g)	0.248

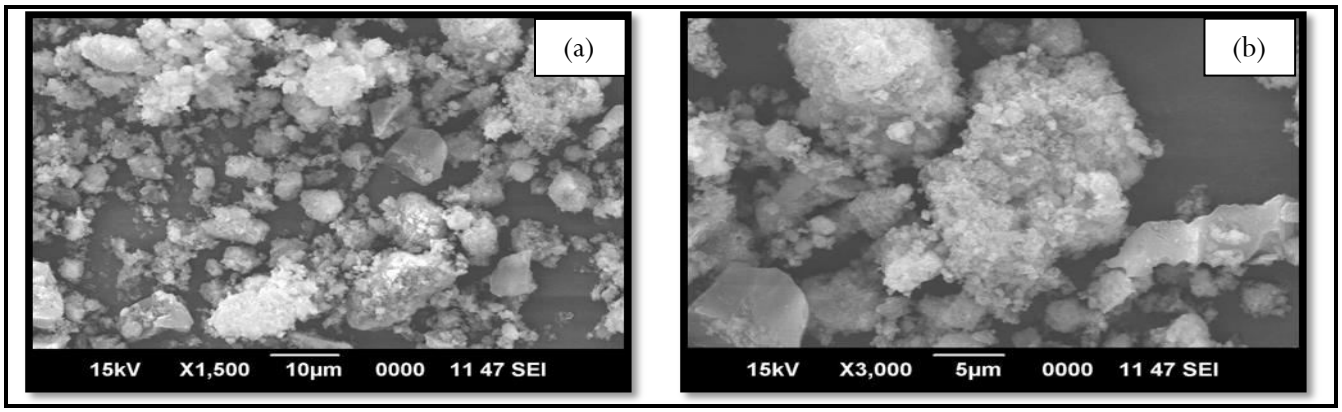

Fig. 2 (a and b): SEM micrographs (10 and 5 µm) of MACFBL adsorption

3.3. Energy Dispersive X-ray (EDX) study

The EDX outcomes of MACFBL material presented in Fig. 3 and Table 2, demonstrating the the number and amount of elements in the adsorbent material. As indicated by the Table 2, it was seen that the MACFBL has the most elevated measure of carbon by weight (46.83%) and (57.02 %) by atom and the least measure of oxygen. Hence MACTIS can use as an efficient adsorbent for the removal of pollutants from aqueous solution.

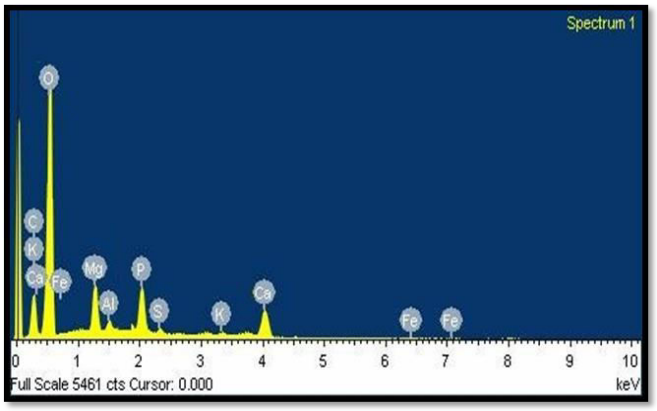

Fig. 3: EDX monograph of MACFBL

Table 2: EDX analysis results of MACFBL.

Element	Weight %	Atomic %
C K	46.83	57.02
O K	34.37	32.44
Mg K	2.38	1.94
Al K	0.35	0.26
P K	2.90	1.85
S K	0.31	0.19
K K	0.24	0.12
Ca K	12.37	6.09
Fe K	0.25	0.09
Total	100	100

3.4. X-ray diffraction (XRD) study

Fig. 4 represents the XRD spectra of MACFBL material. The strong main peak indicates the existence of a very much organized crystalline structure and noises in the XRD patterns shows amorphous nature of carbon material [38, 39]. The peaks in XRD are a direct result of the elements like Ca, Si, K, and Mg as established by EDX. In this result, it might be cleared up that the pyrolytic effect of organic compounds comprises the breaking of chemical bonds with temperature and condensing further into active compounds.

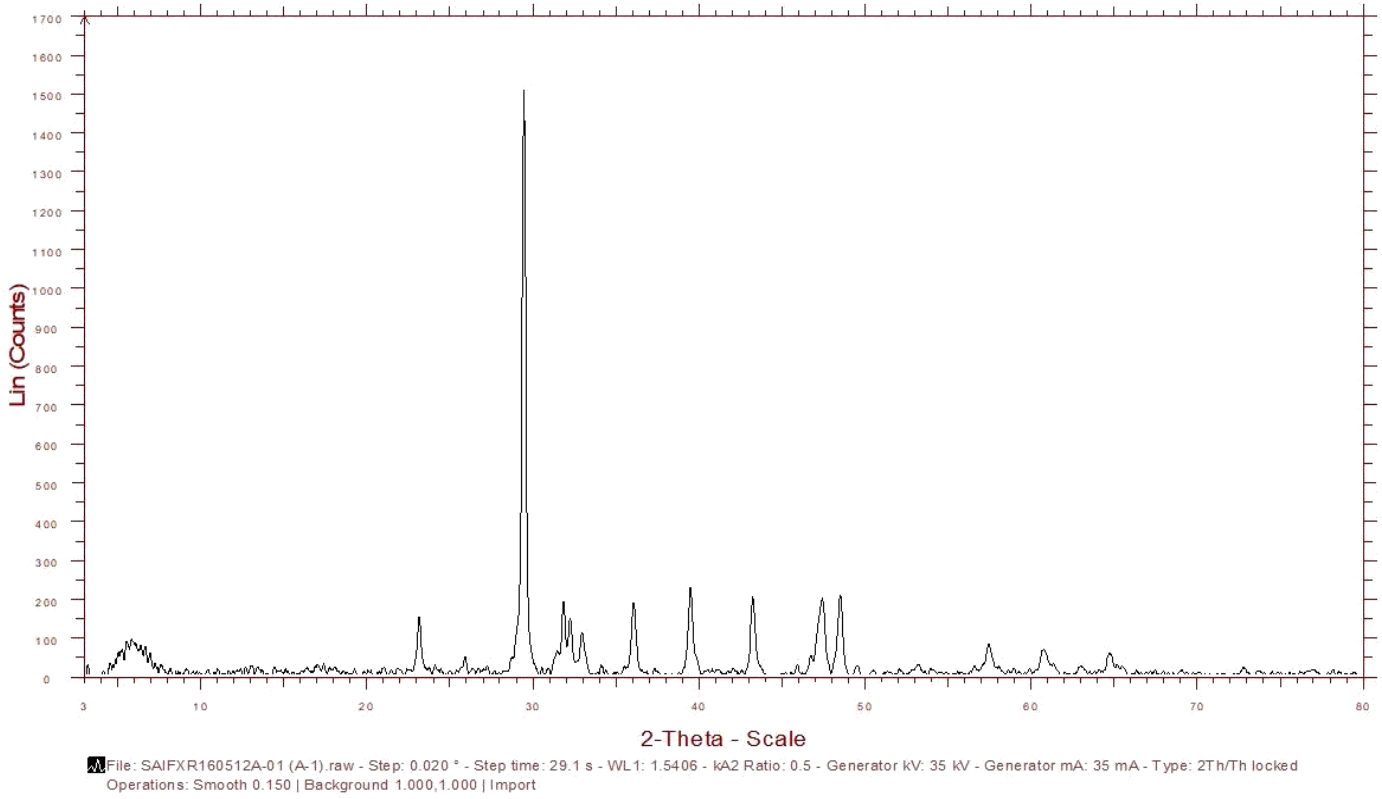

Fig. 4: Powder X-ray diffraction (XRD) of MACFB

3.5. Fourier transforms infrared (FT-IR) study

The FT-IR spectra of the MACFBL carbon material is shown in Fig. 5. The number of peaks represents the adsorptive nature of MACFBL. The peaks in the region 3700 to 3400 cm^{-1} is due to the presence of –O-H and –N-H stretching vibrations. The peaks in the region 2900 to 2500 cm^{-1} represents the $–CH_2$ symmetrical and asymmetrical stretching. The peak region from 1700 to 1400 cm^{-1} indicates the presence of –C=O group of ketones, esters, amide and–C-O-C- of ether. The peaks due to –N-H deformation and bending were observed in the region 1400 to 1500 cm^{-1}. Around 1200 to 500 cm^{-1} region, peaks observed due to the presence of –C=S, -C-N, -C-O,-C-C- and –C-H stretching vibrations and deformations. On the basis of the FTIR study, one can confirm the probable applicability of MACFBL as adsorbent material.

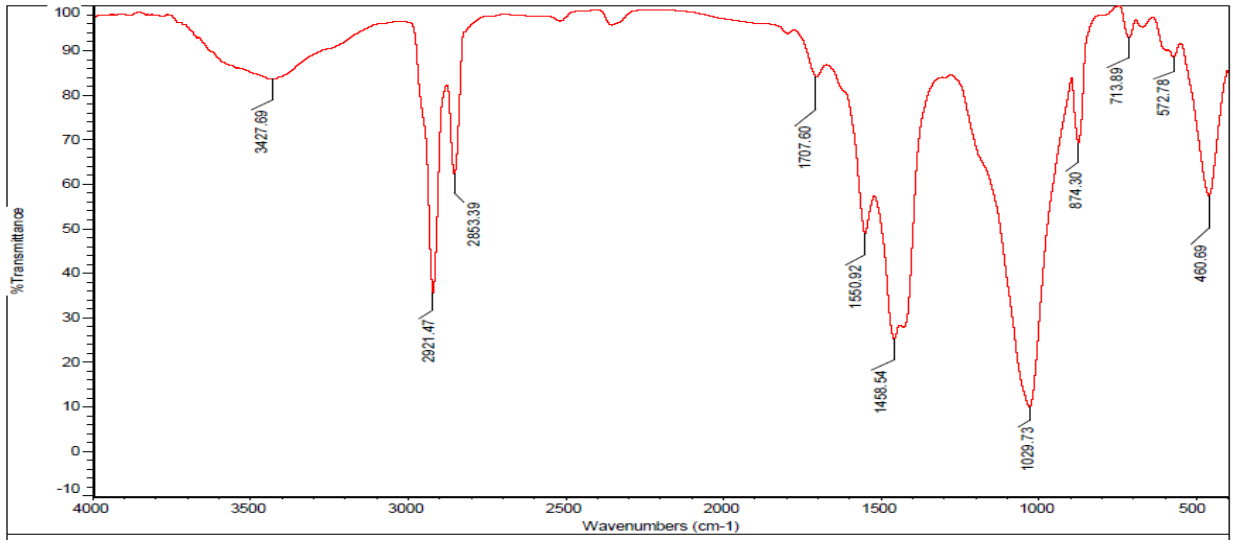

Fig. 5: Fourier transforms infrared (FT-IR) spectra of MAFBL

4. CONCLUSION

In this article, a new microwave assisted and acid-base impregnated carbonized *Ficus benghalensis* leaf (MACFBL) activated carbon was prepared. The synthesized carbon material was characterized by proximate analysis such as bulk density, moisture, ash, volatile matter, fixed carbon content, water soluble and acid soluble matter and ultimate analysis such as elemental analysis, BET surface area, average pore diameter, total pore volume, EDX, SEM, FTIR and XRD. *Ficus benghalensis* leaf (MACFBL) is a potential precursor adsorbent due to its high carbon content, low moisture and ash content. The irregular pores are presents on the surface of carbon material indicate the feasibility of binding sites. The FTIR analysis confirmed the presence of different functional groups on the surface of carbon material. The results of the present investigation show that MACFBL is a good precursor for preparation of potentially useful low cost adsorbent. In conclusion, *Ficus benghalensis* leaf can suitably considered as an alternative low cost carbon material for the removal of pollutants such as dyes, heavy metals, organic pollutants, biological active agents and other hazardous chemicals.

5. ACKNOWLEDGMENTS

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