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Physico-chemical parameters of activated carbon produced from temple waste flowers

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Abstract

The aim of this research work is to produce activated carbon from temple waste flowers by direct pyrolysis process. The product was analyzed based on the following characteristics study includes pH, conductivity, moisture content, ash content, volatile content, mater soluble in water, mater soluble in 0.25 M HCl, bulk density, specific gravity, porosity, methylene blue number, iodine number, fixed carbon, yield and Brunauer-Emmett-Teller surface area (S_{BET}). The activated carbon prepared from the temple waste flowers (TWF) were softened and good porosity, which was verified by Field emission Scanning Electron Microscopy (FeSEM). The elements and percentage of activated carbon in waste flowers were detected by Energy Dispersive X-ray Spectroscopy (EDS). From the analysis, it is concluded that direct pyrolysis process was best method to produce activated carbon from temple waste flowers for the present investigation due to higher surface area, low moisture content, low ash content and better yield.

Keywords: Activated carbon, BET, Characterization, Direct pyrolysis, EDS, FeSEM, Temple waste flowers.

Introduction

In recent times, vast researches are being carried out all over the world to find out the most economical, efficient and successful methods for treating various kinds of wastewater. Among the various methods, the adsorption process is currently being focused at a greater extent due to simple operation, effectiveness, and economical in removing dyes, metal, organic compounds from wastewater. Adsorbents including synthetic resins, alumina, silica and activated carbon are generally used for industrial and commercial applications. Amongst various adsorbents activated carbon is worldwide accepted because it has high adsorption capacity, higher surface area and microporous structure. According to US Environmental Protection Agency the adsorption process by activated carbon[1] is preeminent method in all areas such as water, air purification process etc due to ease of use and availability of raw materials. The naturally existing materials includes coal, wood, coconut shell, etc can be used as best adsorbent at optimum conditions[2]. In recent times many researchers working on agricultural by-products as precursor materials[3-5] in the preparation of activated carbon by some form of activation process. Biomass waste including corn cob[6], coconut shell[7], palm shell[8], apple pulp[9], chickpea husks[10], grain sorghum[11] pistachio nut shell[12], jute fiber[13], olive stones and walnut shell[14], cherry stones[15], coir pith[16], wild rose seeds[17], rice bran[18], gopher plant[19], oil palm shell[20], rubber tree seed coat[21], cotton stalk[22], flamboyant[23] are identified to be right precursor materials since it has rich carbon and low ash contents. Waste flowers are a part of agricultural waste and it is known as aroma waste, organic waste etc.

Waste flowers are generated from a variety of sources, temples are one among them. Tamilnadu is a holy being state therefore people confer a variety of offerings to the divinities which primarily consist of camphor, oil, flowers, fruits, coconuts, clothes etc of which floral offerings are found in huge quantity. After use, these flowers are considered as a waste and dumped into waste lands because there is no appropriate method of disposal and hence waste flowers continuing to accumulate throughout the world today. Commonly dumping of kitchen waste is more as compared to generation of floral waste every day, but the time taken for decaying of floral waste is high than kitchen waste degradation[24]. During decaying process, the waste flowers releases bad odour and toxic gases thereby pollutes the environment and causes several health hazards to inhabitants. The present work is a new approach to produce an activated carbon from temple waste flowers by direct pyrolysis process therefore the volume of waste flowers can be minimized to some extent. Moreover various physico-chemical parameters, SEM along with EDX were studied to confirm the quality of activated carbon.

Materials and methods

Sample collection: The waste flowers for the present investigation were collected from temples in and around Coimbatore district, Tamilnadu, India. The waste flowers includes *Hibiscus Rosa Sinesis, Jasminum polyanthum, Jasminum auriculatum, Chrysanthemum morifolium, Nerium oleander, Tabernaemontana divaricata, Rosa, Nelumbo nucifera, Ixora coccinea, Leucas aspera, Michelia champaca,* *Marigold, Saraca indica* and *Jasminum angustifolium* were washed with distilled water and sun dried. The dehydrated material was grinded with a mixer and used as starting material which is represented as FW0.

Method used for preparation of activated carbon: Direct pyrolysis process: A carefully weighed 10.0 g sample was kept in a clean crucible of known weight and it was then heated in a muffle furnace maintaining temperature at 550°C for a period of 2 h for carbonizing. The product was cooled to room temperature then it was washed with distilled water (pH = 7) to remove colour and impurities and dried in the oven at 110^0C for 2 h. The dried product was crushed to a fine powder using mortar and pestle and it was put through sieves to get sample (FW1) with uniform particle size 110 µm which was stored in an air tight container and used for the present study.

Characterization techniques: The pH and conductivity of the sample FW1 was analyzed using a pH meter (Elico, L1-127) and conductivity meter (CM-180) respectively. Moisture content (%) by mass, ash content (%) by mass, bulk density (g/L), specific gravity, water soluble matter, acid soluble matter, iodine number (mg/g), methylene blue number, BET surface area, total pore volume and pore diameter of carbon was analyzed as per standard procedures[25-27]. The structure, morphology and composition of activated carbon have been characterised using Field emission Scanning Electron Microscope (Carl Ziess, UK) and Energy Dispersive X-ray Spectroscopy (Carl Ziess, UK) respectively.

Results and discussion

Surface characterization of activated carbon: The physico-chemical characteristic values of activated carbon FW1 is recorded in Table-1.

Determination of pH is the important factor mainly for water purification process. According to Ahmedna[28] and Okieimen[3] the carbon pH 6-8 is acceptable for most applications, therefore in the present work the pH of activated carbon FW1 is determined to be 7.63. The proximate analyzes such as moisture, ash and volatile content values are found to be low which is suggesting that the particle density is comparatively small but mechanical strength, adsorptive power, and effectiveness of reactivation of carbon will be high. Other parameters such as solubility, porosity, bulk density, specific gravity, methylene blue number, iodine number, fixed carbon and yield of carbon FW1 has been compared with standard values and the results are shown in Table-1. The BET surface area is crucial parameter because they are closely related to the adsorptive capacities of adsorbent. In the present study, the BET value of the resulting activated carbon was calculated to be 672.2 m^2/g. The value determined is within the limit set by ASTM (600 - 1200 m^2/g), indicating that the temple waste flowers are a suitable carbonaceous material for the present investigation.

Table-1: Physico-Chemical parameters of activated carbon.

Parameters	FW1	Specified range of activated carbon as per ASTM and AWWA
pH	7.63	6-8
Conductivity	0.29	Depends upon the raw material used
Moisture content %	5.2	5-8
Ash content %	4.0	5-15
Volatile matter %	17.4	37. 5 ± 0.03
Matter soluble in water %	0.81	< 1
Matter soluble in 0.25 M HCl %	0.94	< 3
Bulk density, g mL^{-1}	0.48	0.25
Specific Gravity	0.80	≈1.8
Porosity, %	65.0	40-85
Methylene Blue Number, mg g-1	511.5	≈450
Iodine Number, mg g-1	642.0	600 to 1100
Fixed Carbon, %	73.4	Depends upon the raw material used
Yield, %	63.7	Depends upon the raw material used
BET Surface area (m^2/g)	672.2	600 to 1200

The scanning electron micrographs (Figure-1) were taken at two different magnifications (2µm and 10µm) to study the surface morphology of activated carbon. The activated carbon FW1 gives more pores, caves type openings and good surface area. The pores and cavities will increase the adsorptive power of the adsorbent. Moreover the rough surface and bigger holes are observed on the surface of carbon through SEM images. The pore formation is related to temperature of raw materials as a result in the present work the waste flowers are heated at 550ºC in a muffle furnace for 2 hours which causes the material to enlarge and it opens the surface structure. Also the larger pores are highly developed inside the surface of activated carbon. Thus the surface morphological studies using SEM proves that, the activated carbon from temple waste flowers contains more pores providing more sites for adsorption.

The data generated by EDS consist of spectra showing peaks (Figure-2) which confers the idea about the presence of various elements and percentage of carbon in the sample. The elements of carbon given in Table-2, which shows the carbon FW1 has rich amount of carbon 99.45% therefore it is suitable for adsorption studies.

Table-2: Composition and relative proportions of activated carbon by EDS.

Activated Carbon	Elements Present	Percentage
FW1	C	99.45
	Na	0.17
	Mg	0.23
	Ca	0.15
	O	0.00
	Total	100

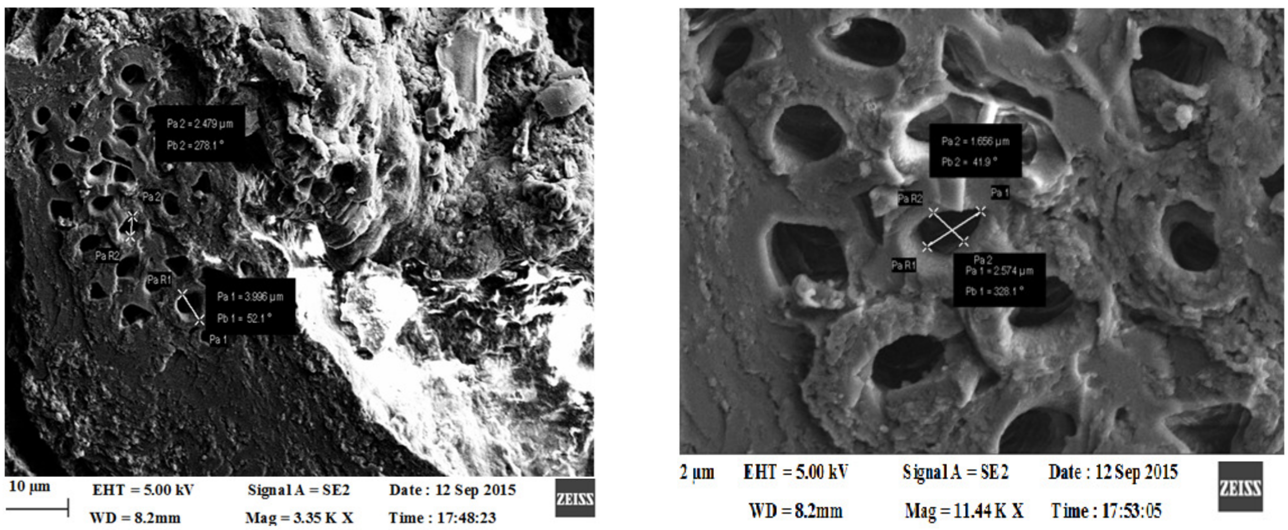

Figure-1: SEM micrograph activated carbon FW1 is shown at two different magnifications (a) 10 µM and (b) 2 µM

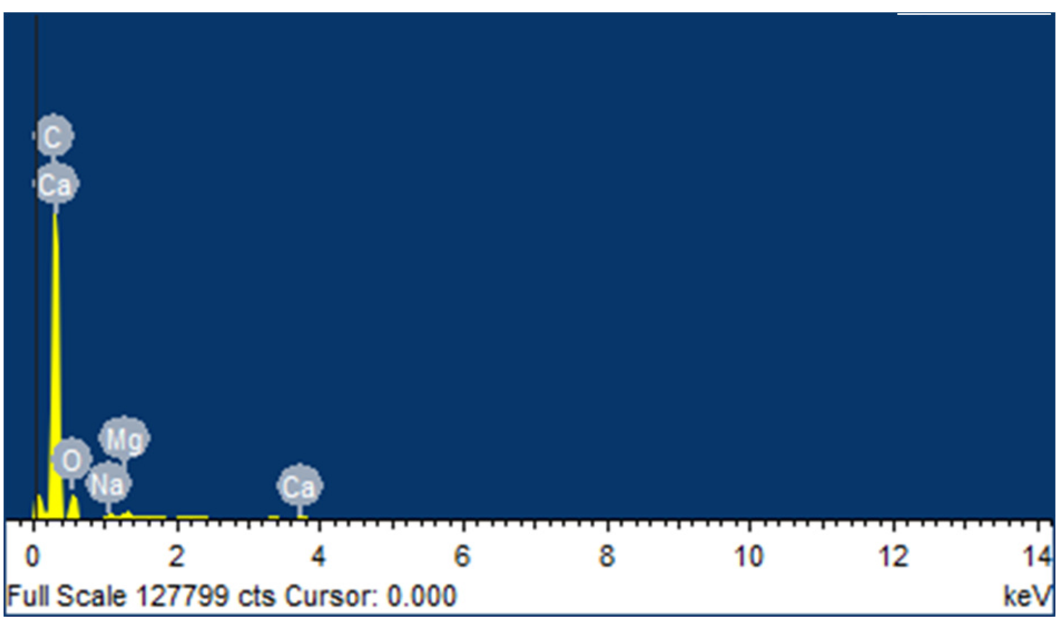

Figure-2: Elemental analysis of activated carbon FW1 by EDS.

Conclusion

There are number of biodegradable waste materials available in our earth for the production of activated carbon to indulge the industrial purposes. The outcome of this paper clearly enlightens the temple waste flowers is a suitable carbonaceous precursor for the production of activated carbon. Based on physico-chemical parameters, BET Surface area, SEM and EDS of the activated carbon FW1 obtained by direct pyrolysis process can satisfy the recommended values by American Society for Testing Materials (ASTM) and American Water Works Association[29] (AWWA). This work provides a simple method to obtain carbonaceous adsorbent from low cost and freely existing material for the treatment of dyes such as methylene blue, methyl violet, methyl red, methyl orange and textile dyeing industrial effluents from Coimbatore and Tirupur district.

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