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Preparation and characterization of activated carbon from *Lantana camara*

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Abstract
The carbon substance known as "activated carbon" has a very porous, amorphous structure. They can adsorb organic pollutants and heavy metals thanks to its active surface. In the current study, *Lantana camara* was impregnated with orthophosphoric acid using a 1:1 impregnation ratio to produce activated carbon utilizing a chemical activation approach. With an activation time of one hour, the activation temperatures employed were 500 °C, 550 °C, 600 °C, 650 °C, and 700 °C. This study shows that, while the adsorption capacity of activated carbon increases with increased activation temperature, activated carbon synthesis decreases as activation temperature rises. According to this study, the highest amount of iodine adsorption occurs when activated carbon is formed at an activation temperature of 700 °C.

Keywords: Activated carbon, *lantana camara*, activation temperature and time, adsorption

1. Introduction
Activated carbon is a form of carbonaceous material with amorphous nature. Because carbon does not graphitize naturally, the material created by the charring process is typically porous. It has a surface that is active and can adsorb molecules physically or chemically (Yahya *et al.*, 2018) [1]. It is possible to make activated carbon from readily available and inexpensive precursors, such as agricultural crops, wood, and its by-products. Given its better porosity, strong adsorption capacity, and lower cost compared to other sources, wood can be selected in this regard as a source for the manufacturing of activated carbon. In general, there are two ways to manufacture activated carbon: physically and chemically. Physical activation methods are a two-stage procedure that begins with the carbonization of organic materials into char by heating in the absence of oxygen and continues with an activation phase utilising an oxidising gas such as air, carbon dioxide, or steam at a high temperature. Before heating in an inert atmosphere using a chemical approach, dehydrating agents such orthophosphoric acid, zinc chloride, sulphuric acid, or potassium hydroxide are impregnated (Mazlan *et al.*, 2016) [3]. Water and sewage treatment, air purification, the food industry, the manufacture of cosmetics, and the pharmaceutical industry are just a few of the industrial uses for activated carbon. Waste and sewage water treatment uses activated carbon as an adsorbent. Additionally, it gets rid of some organic contaminants and chlorine from water. It purifies the air and eliminates dangerous dust particles, odours, and toxic gases in greenhouses and manufacturing facilities (Bhatnagar *et al.*, 2013) [2]. The capacity of carbon nanotubes to adsorb heavy metals like lead and copper III as well as some biological substances has been discovered (Dichiara *et al.*, 2015) [7]. Due to its availability and affordability, activated carbon is now manufactured from agricultural waste (husk, paddy straw), wood, and its by-products. Due to its superior qualities, such as high carbon content and density, minimal inorganic matter, and high pore volume, wood is frequently utilised as the raw material for the manufacturing of activated carbon (Amirza *et al*, 2017) [4].
The invasive species Lantana camara, which is primarily found in forest lands, has been attempted to be converted into activated carbon in the current study. The native floral composition and animal movement are impacted by the predominance of this invasive species in Tamil Nadu's Mudumalai Tiger Reserve and Sathyamangalam Tiger Reserve. As a result, Lantana camara value addition aids in the restoration of indigenous vegetation and provides employment for tribal members and outlying villagers.

The current study's goals are to increase activated carbon production efficiency and analyse the physical-chemical characteristics of activated carbon derived from Lantana camara.

2. Materials and Methods

Lantana camara were obtained from the Mudumalai Tiger Reserve, Tamil Nadu, India. The debris free wood were air-dried for 15 days and made into fine powder by using Willey Mill.

2.1 Preparation of Activated Carbon

Through a single step of pyrolysis, orthophosphoric acid was used to activate Lantana camara. The impregnated powdered wood sample was placed in an 8-hour hot air oven at 105 °C after being impregnated with orthophosphoric acid at a ratio of 1:1. The sample that had been dried in the oven was held in a muffle furnace for a full hour at various activation temperatures, including 500 °C, 550 °C, 600 °C, 650 °C, and 700 °C. The obtained activated carbon washed several times with distilled hot water and was filtered using what man filter paper 1. The sample was then dried in an oven at 120 °C for eight hours.

2.2 Characterization of Precursor

2.2.1 Proximate analysis

A. Moisture content

The moisture content of the raw material for preparation of activated carbon was determined according to the T 258 om-94 (TAPPI). 100 g of wood samples was kept into hot air oven and incubated at 105 °C for 8 hours.

$$\text{Moisture content \%} = \frac{(\text{weight of the original of sample} - \text{Weight of the sample after drying})}{\text{Weight of the original sample}} \times 100$$

B. Ash content

The ash content of the raw material was calculated by using ASTM D3172-89 (ASTM, 2002). 1 gram of ash content was taken in pre-weighed silica crucible and kept into muffle furnace at 450 °C for 2 hours. The ash content was determined using the following formula.

$$\text{Ash content \%} = \frac{(\text{Weight of the final ash} - \text{Weight of the empty crucible})}{\text{Weight of the original sample taken}} \times 100$$

C. Volatile matter

The volatile matter of the sample was determined using ASTM D3175 (ASTM, 2002). On gram of dried powdered sample was taken in pre-weighed crucible and kept into muffle furnace at 600 °C for 6 minutes. The volatile matter can be calculated by using the following formula

$$\text{Volatile matter \%} = \frac{(W1 - W2)}{(W1 - W3)} \times 100$$

W1 = Weight of the crucible + Sample
W2 = Weight of the final ash present in the crucible
W3= Weight of the empty crucible

D. Fixed Carbon

The fixed carbon of the sample was derived by subtracting ash content and volatile matter of the original sample. The fixed carbon can be calculated by using ASTM D3172-89 (ASTM, 2002) which follows

Fixed Carbon % = 100 – (Ash content + Volatile Matter)

E. Determination of Holocellulose

Five (5.00 ± 0.01) g of O.D. sample was placed in 250ml conical flask and sample was wetted thoroughly with 10ml of distilled water. Then 150ml distilled water, 1.5g of sodium chlorite and 0.5ml of acetic acid were added and conical flask was closed by small flask in inverted position. The contents were kept in water bath at 70 °C for one hour. After one hour, the supernatant was transferred to a tarred crucible (W1). The treatment was repeated with water, sodium chlorite and acetic acid. The contents were the filtered into a tarred crucible and residue was washed with acetone. The contents were dried with crucible in an oven at 105 °C overnight and weighed (W2). Percentage Holocellulose was calculated using the formula.

$$\text{Holocellulose (\%)} = \frac{W2 - W1}{\text{OD Weight of the sample}} \times 100$$

F. Determination of acid insoluble lignin

AB extracted samples each weighing 1.00±0.01 g were placed in a beaker of 100 ml volume. Samples were wetted thoroughly with 2 ml of 72.0 per cent H_2SO_4 solution and then 130 ml of 72.0 per cent H_2SO_4 was poured in it. The beaker was then kept in water bath at 20 °C for two hours and the contents were stirred with the help of glass rod. The contents were filtered through tarred G2 crucible (W1), washed with hot water and the residue with crucible was weighed (W2) and the determination made in duplicate. The percentage lignin content was calculated using the formula.

$$\text{Acid Insoluble Lignin (\%)} = \frac{W2 - W1}{\text{OD Weight of the sample}} \times 100$$

2.3 Characterization of Prepared Activated Carbon

2.3.1 Activated carbon yield (%)

The Activated carbon yield can be calculated by using the formula.

$$\text{AC Yield percentage} = \frac{Wf}{Wi} \times 100$$

Where W_i is the initial weight of the raw material and W_f is the final weight of product.

2.3.2 Iodine Adsorption Test

Iodine adsorption indicates the materials adsorption capacity of smaller molecules. It is the amount of iodine adsorbed by a carbon and it was determined by following the method prescribed by (Ahmedna *et al.*, 1997) [6]. A stock solution of iodine was prepared by dissolving 2.7 g of Iodine and 4.1 g of potassium iodide in 1 L of de-ionized water. In a 250 ml flask, the powdered activated carbon (0.1 g) was taken and 10 ml of 5% HCl was added. Then 100 ml of stock iodine solution was added to it and the mixture was shaken for 5 minutes in an orbital shaker. A blank was prepared without activated carbon. All the samples were filtered through what man No. 1 filter paper. 15 ml of filtrate was titrated with 0.1M sodium thiosulfate until the solution become pale yellow. Then 1 ml of starch indicator was added and the titration was continued with the same sodium thiosulfate until the solution become colorless. The Percentage of Iodine Removal (PIR) was calculated by following formula:

$$PIR\ (\%) = \frac{(\text{ml of Sodium thiosulfate used for balnk} - \text{ml of Sodium thiosulfate used for sample})}{\text{ml of Sodium thiosulfate used for sample}} \times 100$$

3. Results and Discussion

3.1 Proximate analysis

Proximate analysis such as a moisture content, ash content, volatile matter and fixed carbon is determined for the betterment of activation process. The moisture content of the Lantana is high (52.81%) than other woody species. The fixed carbon was 22.56% which slightly higher than agricultural residues.

Proximate analysis

Physical properties				Chemical properties	
Moisture content (%)	Ash content (%)	Volatile matter (%)	Fixed Carbon (%)	Holocellulose (%)	Acid Lignin Content (%)
52.81	3.98	73.46	22.56	81.49	20.12

3.2 Effect of activation temperature on activated carbon yield

The activated carbon yield is decreasing with an increasing in an activation temperature. Similar result was obtained in the study conducted by Yorgun and Yildiz (2015) [8] in the production of activated carbon from Paulownia wood at various activation temperatures which are 300 °C, 400 °C, 500 °C and 600 °C.

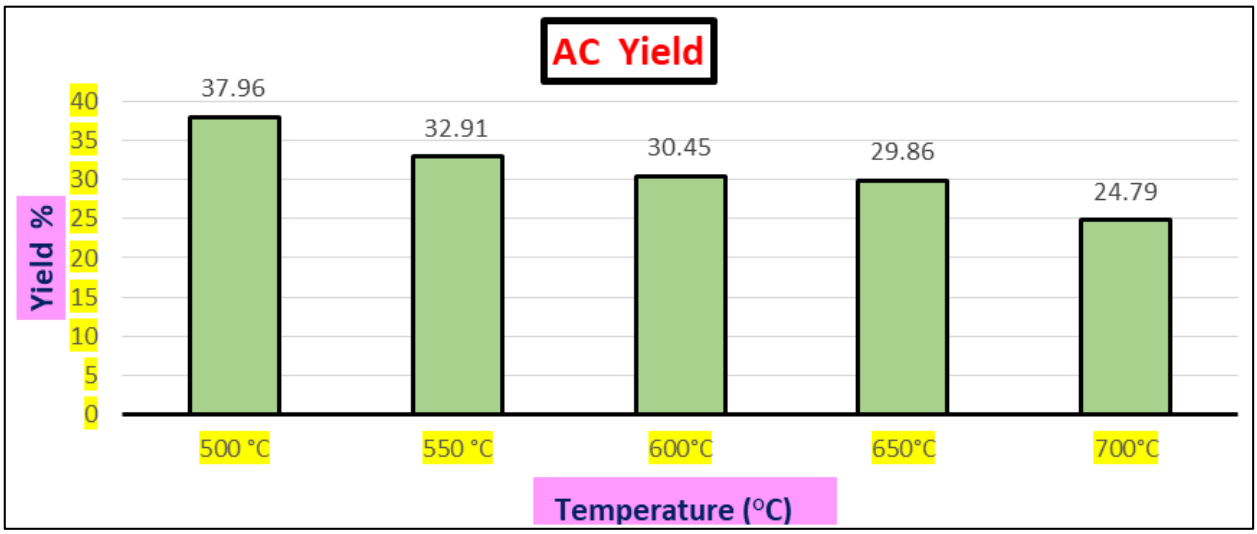

Fig 1: Activated carbon yield (%) from Lantana camara

3.3 Iodine Adsorption experiment

The Percentage of Iodine removal by an activated carbon is an indicator of its ability to adsorb low molecular weight compounds. The maximum adsorption of iodine (59.37%) was observed with activated carbon produced at the activation temperature of 700 °C while the lowest adsorption (18.75%) was with activated carbon produced at 500 °C activation temperature. Thus, iodine adsorption of an activated carbon increases with increase in an activation temperature. Similarly the study conducted by (Mopoung *et al*., 2015) [9] showed that the highest adsorption of iodine was with activated carbon produced at an activation temperature of 700 °C.

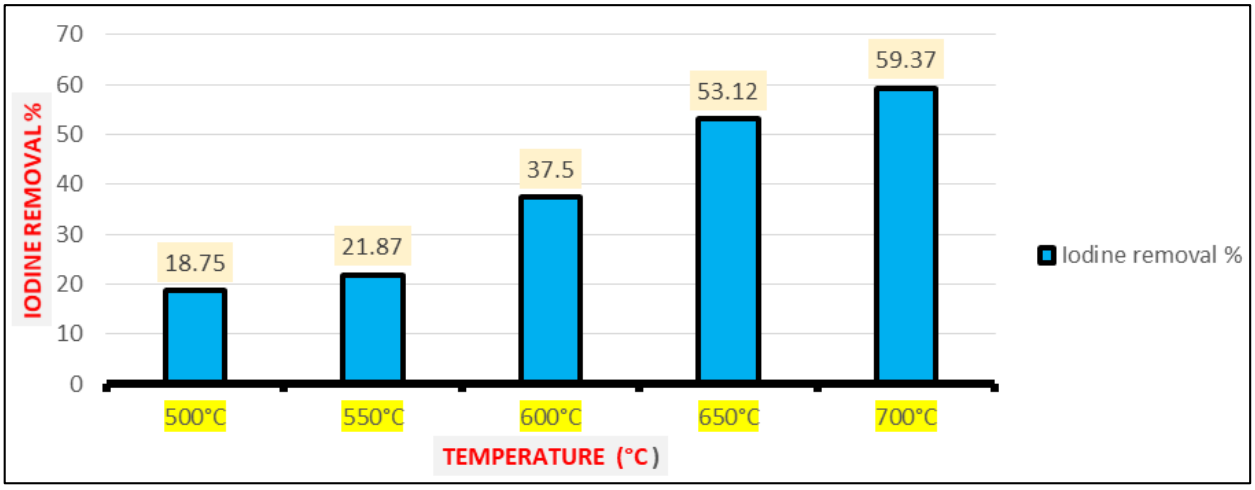

Fig 2: Iodine removal (%) of Lantana derived activated carbon

Conclusion

This study found that increasing in activation temperature resulted in decrease in yield and meanwhile increased adsorption capacity of the activated carbon. Hence, it may suggested that the activation temperature plays an important role in enhancing the potential of an activated carbon in adsorbing organic contaminants and heavy metals.

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