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PREPARATION OF NONTOXIC ACTIVATED CHARCOAL FROM GULMOHAR (*Delonix regia*) SHELL

M. Chandrakala[1] and Anima Upadhyay[2]
[1]Research Scholar, Research and Development Centre, Bharathiar University, Coimbatore, Tamil Nadu, India
[2]Assistant Professor, Department of Chemistry, Sir MVIT, Bangalore, Karnataka, India
E-mails: [1]chandbk@gmail.com, [2]animaupadhyay@gmail.com

Abstract: An efficient, cost effective, rapid and convenient method has been developed for preparation of activated charcoal (AC) from sun dried Gulmohar (*Delonix regia*) fruit shells as precursors. Activation of the precursor was brought about by phosphoric acid as it is non-toxic and suitable for treating potable water. The various parameters such as Concentration, activation time and impregnation ratio of the activating agent was investigated. Carbonization was conducted at different temperatures (300^0C, 350^0C 400^0C and 450^0C) to get the best results in the terms of quality and the yield of AC. Holding time at different temperatures was also studied during carbonization. The method was found to be superior then many other existing methods in terms of its cost, efficacy and ease of preparation.

Keywords: Gulmohar shell, Precursor, Activated charcoal, Activating agent, Impregnation ratio, Carbonization.

Introduction

Activated charcoal has a great demand in modern times. It is used for various purposes and is an ingredient of many industrial products. Recently, it has become a popular option in water purification due to its adsorption quality and low cost availability. AC also finds applications in medical and pharmaceutical industries, body care products, food industries, electrical and electronic industries and Nano materials.

Production of AC is a long and tedious process which requires large amount of energy and high temperatures for its production. Collection or purchase of raw materials as precursors is very expensive. Selection of activating agent is another important step in its production. Zinc chloride [12 – 15] is the most widely used activating agent which is extremely hazardous for health even if present in traces and has a proven high toxicity level. The other activating agents employed for the preparation of AC are NaOH [1-4], H_2SO_4 [5-7], Na_2CO_3 [8], steam activation [9], KOH [10], $MgCl_2$ [11], Steam – N_2 [12].

Use of phosphoric acid as activating agent [10,11] got very little attention despite its nontoxic nature. In the present study phosphoric acid has been used as the sole activating agent for the

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activation of the precursor. The various parameters such as concentration of activating agent, activation time and impregnation ratio has been studied in detail. The yield and quality of charcoal produced with H_3PO_4 is better compared to the quality and the yield of AC activated by other activating agents described above. Gulmohar is abundantly available locally and it is easy to collect its pods therefore, it can be an ideal inexpensive raw material as precursor for AC. Conversion of these fruit shells, which are otherwise a plant residue and treated as waste, into a useful nontoxic product can be a good example of generating wealth from waste.

Material and Methods

Raw material

Gulmohar fruit shells were taken as precursor for the preparation of activated charcoal. The fruit shells were washed several times with water to remove adhered dust particles from its surface. The shells were then air dried in sunlight for several days. The sun dried shells were then crushed to a desired particle size using domestic mixer. The crushed and grinded shells were washed with distilled water to remove the fine dust. It was then dried in hot air oven at low temperatures for 2-3 hours and stored in airtight plastic bottles.

Activating agent

The activation of the air dried precursor was carried out by chemical activation method using phosphoric acid as the activating agent. The grinded material was immersed in phosphoric acid solution and the impregnation ratio was in the range of 1.25 to 5.0 with an increment of 1.25. The impregnation ratio (IR) was determined as the ratio of the weight of activating agent to the weight of the raw material.

Activation time

A20% phosphoric acid was selected to study the effect of activation time. The dried material (3g) was soaked in 25ml of phosphoric acid solution for 3-9 hours at room temperature. After the lapse of activation hours the sample was decanted and dried in a hot air oven at 70^0C for about two hours.

Carbonization temperature

The dried activated sample was carbonized in muffle furnace. The temperature of the furnace was gradually increased to the final preselected temperature ranging from 300^0C to 450^0C in an inert atmosphere. After attaining maximum final temperature it was hold for 15 minutes.

Washing

Activated charcoal was washed several times with hot distilled water to get rid of unused excess Phosphoric acid. The washed charcoal was dried in hot air oven at 110^0C for three hours. The dried product was weighed and the percentage yield was calculated and was stored in airtight bottles.

Yield

The percentage yield of the activated charcoal was calculated using the formula:

$$\text{Yield }(\%) = \frac{W_1}{W_2} \times 100$$

Where W_1 is the dry weight (g) of final activated charcoal and W_2 is the dry weight (g) of precursor.

Results and Discussion

Effect of carbonization temperature on Percentage yield of Activated carbon

The yield of AC decreased with rise in carbonization temperature as shown in the figure (Fig 1). The decrease in the yield of AC was studied at different concentrations of phosphoric acid (5-20%) and in each case it was found that there is a significant decrease in yield with rise in temperature. This could be attributed to the removal of volatile matter along with the dehydration of the activated material during carbonization. A carbonization temperature of 300°C to 400°Cshowed little change in percentage yield of AC, but at 450°C the yield dropped significantly beyond which it almost became constant. This suggested that 450°C is optimum temperature for carbonization for the above activated material.

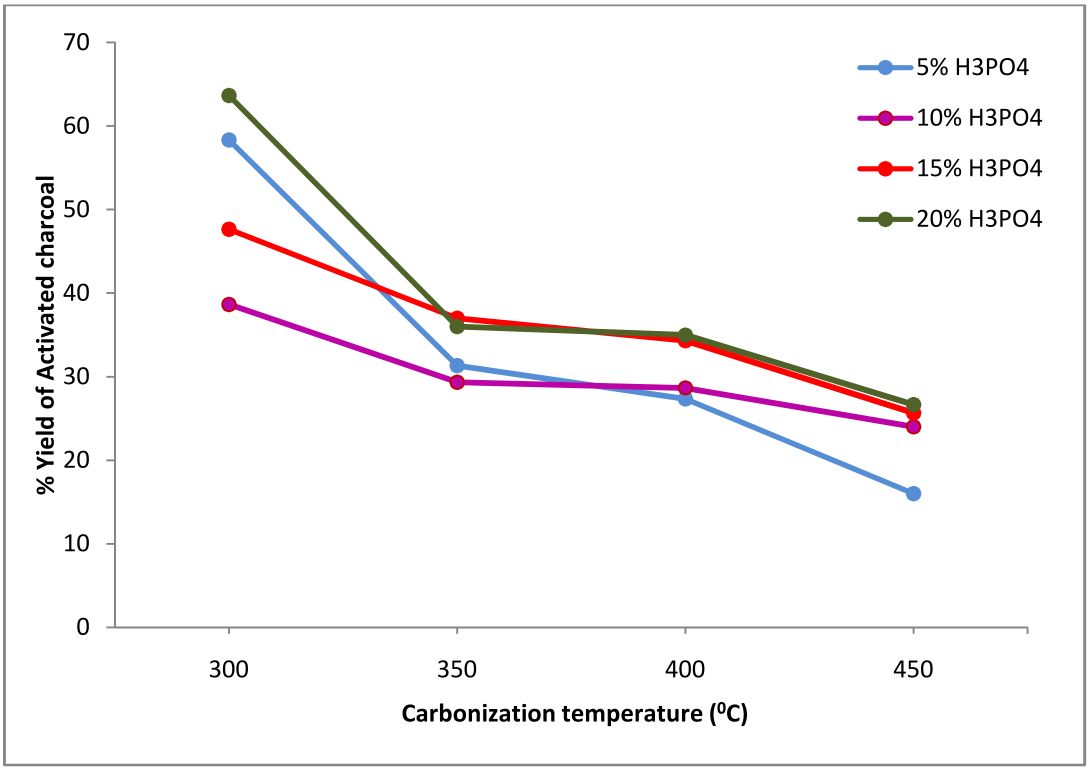

Fig 1: Effect of carbonization temperature on percentage yield of AC

Effect of impregnation ratio on percentage yield of activated carbon

The impregnation ratio (IR) had a great impact on the yield of the AC as shown in figure (Fig 2). With the increase in the IR the yield of the AC increases. This may be due to the increase in cross-linking, and reduction of tarring in the AC which led to the development of innumerous pore structures in the charcoal making it a better quality charcoal for adsorption. A 15% concentration of phosphoric acid showed almost a constant yield at 350^{o}C but with 20% concentration the yield increased rapidly at 450^{o}C. This suggests that an IR of 5 is best ratio to obtain a quality activated charcoal.

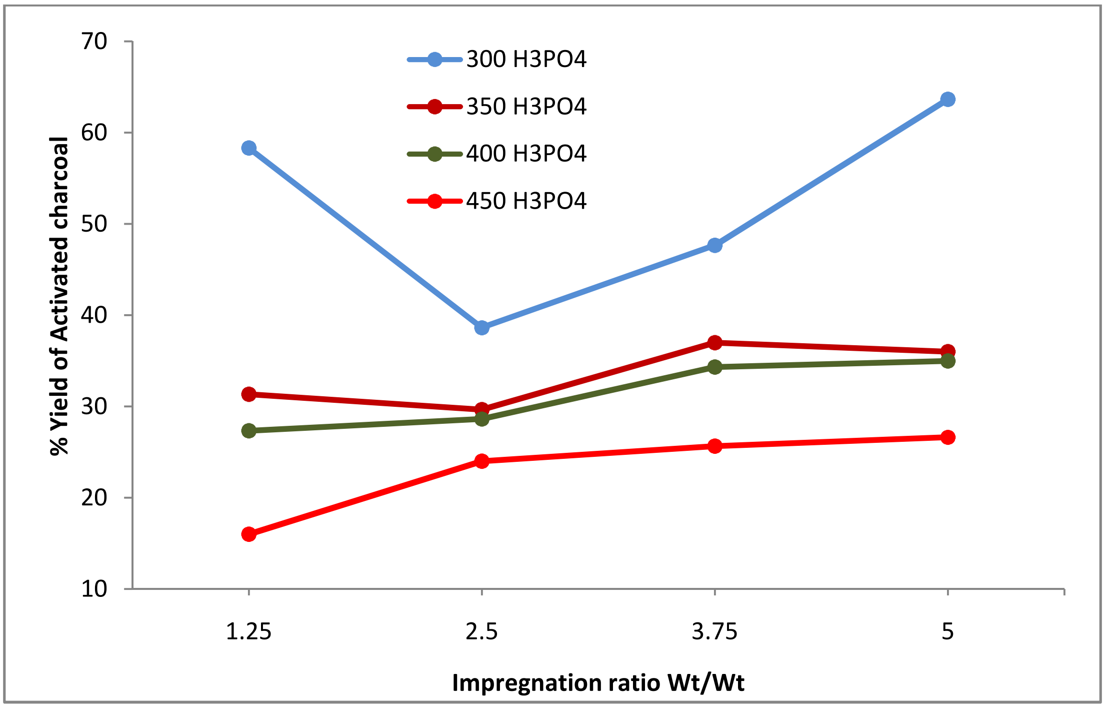

Fig 2: Effect of Impregnation ratio on percentage yield of AC

Effect of activation time on percentage yield of activated carbon

Activation time of six hours was found to be optimum for getting desired activation of the precursor as further increase in activation period did not had much effect on the yield of the AC. Therefore an activation period of 6 hours was found to be optimum for producing AC from phosphoric acid as activating agent. (Fig 3)

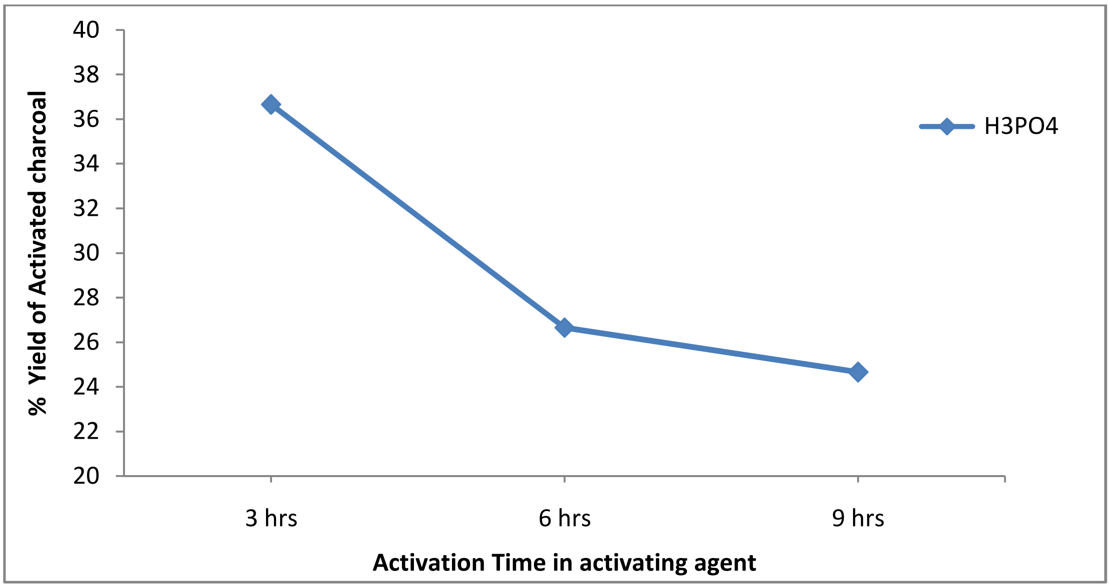

Fig 3: Effect of Activation time on Percentage yield of AC

The phosphoric acid activation method is superior to other existing methods especially zinc chloride activation method which is commonly employed for preparation AC from Gulmohar pods in the terms of various parameters such as yield, carbonization temperature, activation time, and toxicity.[12-15]

Table 1: Comparison of Phosphoric acid and Zinc chloride activation on various parameters

Activating agent	Yield (%)	Carbonization Temperature (^{0}C)	Activation time (Hrs)	Steps involved for AC	Toxicity
H_3PO_4	26.66	450	6	2 steps	Non toxic
$ZnCl_2$	33	800	24	Multiple steps	Highly toxic

Conclusion

Thus the authors conclude that the method developed using phosphoric acid is highly efficient compared to zinc chloride (Table 1) and require less time and energy for production of highly porous nontoxic AC from Gulmohar fruit shells which is a throw-away waste thus converting it into a highly useful product.

Acknowledgement

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