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Wood Apple Fruit Shell *(Limonia acidissima)* an Excellent Precursor for Preparation of Activated Charcoal

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Abstract: **A cost effective, rapid and convenient method has been established for preparation of activated charcoal from sun dried Wood apple fruit shell as precursors using acetic acid as activating agent which is nontoxic and suitable for treating potable water. The various parameters such as activation time, Concentration and impregnation ratio of the activating agent was analysed. Carbonization was conducted at different temperatures in the range of 300 ^{0}C to 450 ^{0}C to get the best results in the terms of quality and the yield of activated charcoal. The method was found to be superior compared to other existing methods in terms of its cost, efficacy and ease of preparation.**

Keywords: **Wood apple fruit shell, Activated charcoal, Acetic acid, Impregnation ratio, Carbonization**.

1. INTRODUCTION

Activated charcoal has a great importance in ancient times and used for various purposes. Recently, it has become a popular option in water purification due to its high adsorption quality, low-cost and easy availability. Activated charcoal finds applications in medical and pharmaceutical industries, food industries, body care products, electrical and electronic industries and Nano materials. Production of activated charcoal is a lengthy and tedious process which requires large amount of energy and high temperature. Cost of raw materials as precursors is very expensive. Selection of activating agent is another significant step in its production. The activating agents employed for the preparation of activated charcoal 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], $ZnCl_2$ [13 – 15], H_3PO_4 [16]. Most of the activating agent are extremely hazardous for health even if present in traces and has a proven high toxicity level. Use of acetic acid [17] as activating agent for the activation of the precursor has been preferred recently due to environmental and economic concerns. Activated charcoal are produced from various precursors. These precursors are usually fossil based hydrocarbons (e.g. bituminous coal, lignite), natural biomass (lignocellulosic materials), biomass waste, polymers and carbonaceous wastes. As a result of increasing demand for adsorbents locally available waste carbonaceous materials have proven worthy for producing activated charcoal [18]. In search of alternative sources and cheaper carbons, agro wastes with average carbon content of 35 percent have attracted the interest of researchers [19, 20]. Wood apple fruit shell is abundantly available locally therefore, it can be an ideal inexpensive raw material as precursor for activated charcoal. The various parameters such as concentration of activating agent, activation time and impregnation ratio has been investigated. The yield and quality of activated charcoal produced using acetic acid as activating agent is better compared to the quality and the yield of activated charcoal activated by other activating agents described above.

2. MATERIAL AND METHODS

A. Raw material

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

B. Activating agent

The activation of the air-dried WFS was carried out by chemical activation method using acetic acid as the activating agent. The grinded material (3.11mm) was soaked in acetic acid solution and the impregnation ratio was in the range of 3.5 to 12.25. The impregnation ratio was determined as the ratio of the weight of activating agent to the weight of the raw material.

C. Activation time

A 40% acetic acid was selected to study the effect of activation time. The dried material (3.0 g) was soaked in 50 ml of acetic acid solution for 12-48 hours at room temperature. After the lapse of activation hours, the sample was decanted and dried in a hot air oven at 70 ^{0}C for about two hours.

D. 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 ^{0}C to 450 ^{0}C in an inert atmosphere. After attaining maximum final temperature, it was hold for 15 minutes.

E. Washing

Activated charcoal (WFS-AC) was washed with distilled water to get rid of the excess of acetic acid and was dried in hot air oven at 150 ^{0}C. The dried product was weighed and the percentage yield was calculated.

F. Percentage yield

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

$$\text{Percentage yield} = \frac{W_1}{W_2} \text{ X } \% \ 100$$

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

3. RESULTS AND DISCUSSION

A. Effect of activation time on percentage yield of WFS-AC

Activation time affects the percentage yield of the activated charcoal. The results obtained from this parameter for WFS-AC showed that soaking of precursor for 24 hours at room temperature in 40% acetic acid gave good activation results (Fig 1).

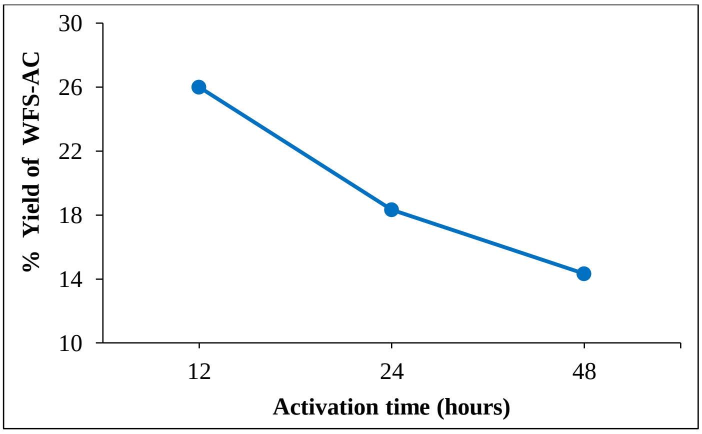

Fig 1: Effect of activation time on percentage yield of WFS-AC

B. Effect of impregnation ratio on the yield of WFS-AC

The impregnation ratio had a great impact on the yield of the activated charcoal (Fig 2). The impregnation ratio of 3.5 and 12.25 showed maximum yield whereas it dropped to a minimum at impregnation ratio 7.0.

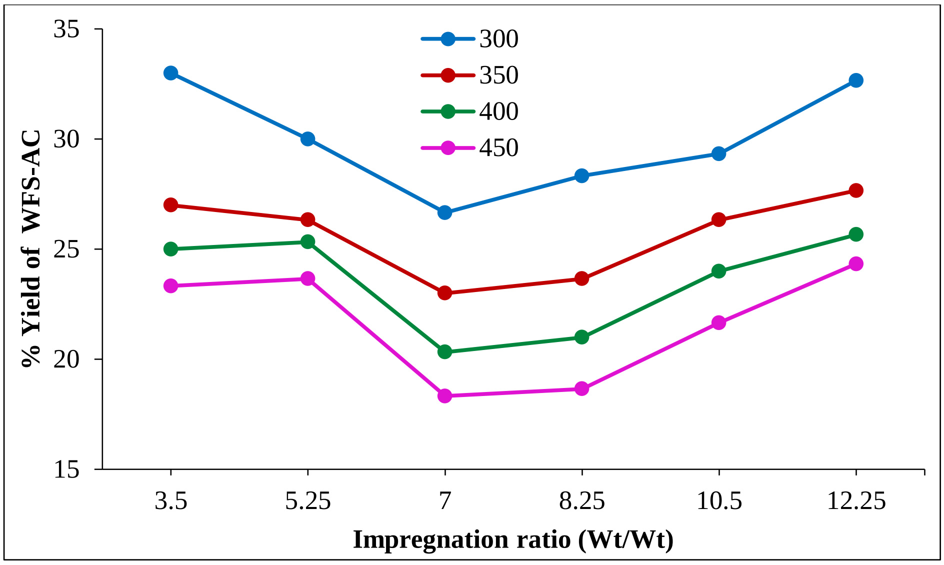

Fig 2: Effect of impregnation ratio on percentage yield of WFS – AC

C. *Effect of carbonization temperature on the yield of WFS-AC*

The effect of carbonization temperature and concentration of acetic acid on the yield of WFS-AC is shown in the Fig 3. The yield of activated charcoal decreased with the rise in temperature (300 - 450 ^{o}C). The effect of concentration of acetic acid (20 – 70%) was studied and the results showed lowest yield at 40% and highest at 70% concentration of acetic acid within the above range of temperatures. The decrease in the yield could be attributed to the removal of volatile matter, dehydration of the activated material and breaking of C – H & C – O bonds along with the formation of C – C bonds during carbonization [21, 22]. This breaking and making of bonds could lead to the increase in pore distribution and pore volume. The carbonization temperature of 400 - 450 ^{o}C showed a significant drop in the yield as shown in Fig 3.

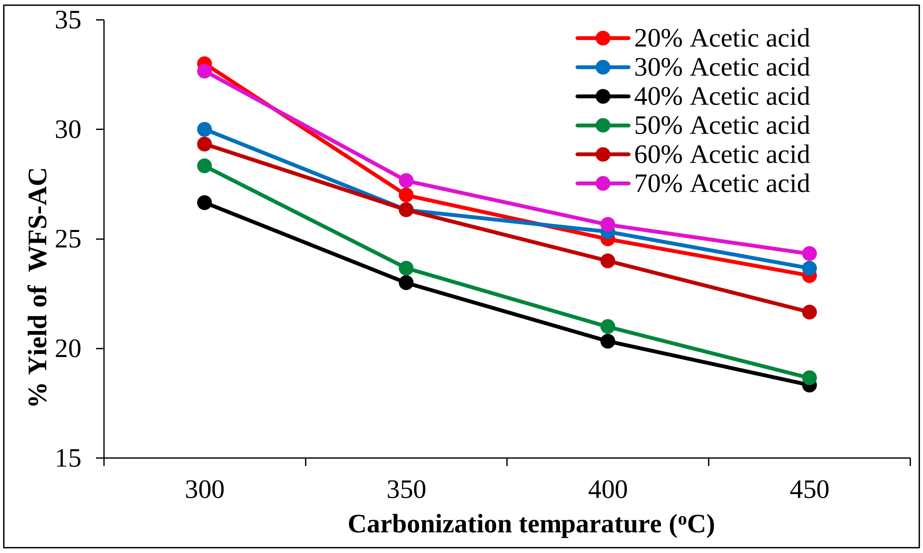

Fig 3: Effect of carbonization temperature on percentage yield of WFS-AC

4. CONCLUSION

Wood apple fruit shell for preparation of activated charcoal can be used successfully as precursors. Use of Acetic acid as activating agent for its activation gives it a non-toxic nature. The decrease in yield makes it highly porous and adsorption efficient thus making it ideal for water purification and medical industry.

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