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Procurement of Activated Carbon from Jacaranda (Mimosifolia)

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Abstract*— Activated carbon is one of the most widely used absorbents and it can be produced from a variety of carbon-rich materials. In this work the absorptive capacity of the activated carbon obtained from jacaranda (mimosifolia) was evaluated as precursor and chemical activation from phosphoric acid. The immediate analysis of the starting raw material (Jacaranda Mimosifolia) shows a 1.89 % moisture, ash percentage of 15.70%, 2.96 % volatile matter and fixed carbon 81.39 %, results that allow its feasibility as a starting material for activated charcoal at low concentrations (0.0025mg / L) of methylene blue affinity of activated carbon is null. However at high concentrations (0.01 mg / L) it is obtained by an affinity adsorption of methylene blue allowing saturation to an 80.43 %. In the photomicrographs obtained, two types of approaches 65x and 1000x, cavities were observed with a high degree of roughness and uniformity. These spaces are on the order of 10µm.

***Index Terms*— Activation, chemical, coal, jacaranda.**

I. INTRODUCTION

Activated carbon is a widely used absorbent and it can be obtained from a variety of carbon-rich materials [1]-[2]. The precursor's choice is primarily a function of availability, price and purity, without forgetting the manufacturing process and the possible application of the final product [3]. Manufacturing processes can be divided in two types: physical activation (also known as thermic) and the chemical activation [4]. Several authors have documented the process of chemical activation of the biomass waste precursors such as coconut shell [5]-[6], bamboo waste [3], stems of eucalyptus wood [7]-[8], coffee huts [9], forest residues [10], sugar cane bagasse and corn juice [11]. These studies indicate the use of H_3PO_4 as an agent for obtaining activated carbon which represents several advantages over the physical activation since it involves a single heat treatment phase and it requires lower temperature range between 400°C and 750°C. This allows an efficient recovery of acid by multistage extraction and higher yields and adsorption capacities are reached reducing the process costs. Under this background, the production of activated carbons from jacaranda's rind has not been thoroughly investigated. The purpose of this paper is to evaluate the adsorption capacity of activated carbon obtained from the skin of jacaranda (*mimosifolia*) via chemical activation with phosphoric acid.

II. MATERIALS AND METHODS

A. Collection of raw material

Jacaranda (mimosifolia) is a deciduous tree of 8-20 m high and 40-70 cm in diameter. It has a wide treetop with long branches and a straight trunk with a cylindrical and gently corrugated base. The outer bark is light brown, semi-rough with small cracks which shed in rectangular scales. The inner bark is thin and it has a golden to yellowish color. The total shell thickness ranges from 4 to 6 mm. The leaves are compound, opposite, pinnate and 50 to 60cm long. Each pinna with 15-30 pairs of lanceolate leaflets, 5-10 mm long, acute apex, unequal base, dark green beam and light green underside.

The collection of the fruit (Figure 1) was performed during the months of April and May, from 10 randomly selected trees in the community of Francisco I. Madero in the town of Tepatepec in the state of Hidalgo at the geographical coordinates 20°15´N, 99°05´W at an altitude of 1960 meters above sea level. This is the time of the year when fruits, which are characterized by being a dehiscent capsule, rounded, flattened, blackish, with wavy edge, 5-7 cm long and opened in two parts, are produced. Once collected, the fruits were transported in jute bags to the processing site where they were placed for drying in the sun for two to three days to allow their opening.

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Fig 1: jacaranda fruit

B. Preparation of activated carbon

50 grams of jacaranda, previously ground in a pulvex mill model 200 of 5 Hp, were weighed. Then they were placed in a glass container and 50 ml of phosphoric acid at 37% (p/p) were added to obtain a smooth paste. Phosphoric acid increases carbon aromaticity, aliphatic character loss and formation of a cross-linked rigid solid. The product obtained was stirred at a temperature of 120°C for a period of 24 hours. Afterwards, it was sintered in a muffle Felisa FE-340, and electrically heated to a temperature of 550°C for about an hour. After this time, the activated carbon obtained was washed with 100 ml of concentrated hydrochloric acid of 37% continuing with its stirring for 6 hours. Once this period was finished, the activated carbon was filtered and washed with distilled water until an electric conductivity of 10-15 mS was obtained. The sample was dried in a Felisa FE-293 furnace at a temperature of 105°C to constant weight for approximately 1 hour. After this time, the product was ground in a mortar and sieved in a mesh No. 35-ASTM.

C. Activated carbon characterization

Once the dry base was prepared, it was subjected to a characterization process, performing the respective immediate analysis: humidity (ASTM D3173-87), volatile material (ASTM D3175-82), ashes (ASTM D3174-89), the fixed carbon was calculated by difference from the results obtained from the volatile material and ash. The activated carbon obtained through chemical activation was characterized under the following parameters: methylene blue bases on the ASTM-D3860 norm. For the morphological characterization a Scanning Electron Microscope, model Jeol JSM-6300, was used.

III. RESULTS AND DISCUSSION

A. Proximate analysis

Table 1 shows the proximat analysis of the raw/starting material (Jacaranda Mimosifolia) in relation to the moisture content which is lower (1.8%) to the one reported in the literature. Humidity is an important factor to predict the behavior during storage: a plant sample with moisture content below 15% is less susceptible of moldiness [12]. Therefore it would be less likely to deteriorate by the presence of fungi.

The ash percentage is higher (15.70%) compared to other raw materials reported by different authors [11]-[13]-[14] which range from 3.8 to 6.4%. Nevertheless, it has been reported that the ashes from leaves and stems mainly contain calcium and potassium salts, since they are the elements mostly absorbed by plants [15].

Table 1. Proximate analysis of the raw/starting material

Sample	Humidity	Ashes	Volatile material	Fixed carbon
	% (w/w)			
Jacaranda	1.89	15.70	2.96	81.34

The volatile material content in the starting sample is low (2.96%), and the fixed carbon is high (81.39%), making

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it a good precursor for obtaining activated carbon. Similar results have been reported in materials such as the rachis of African palm [13].

B. Methylene Blue Index

Figure 2 shows the data of the standard curve of methylene blue that were used for the analysis of the methylene blue amounts on the studied carbons. The results were attuned to a straight line and a good correlation coefficient of R2 0.9998 was obtained. The high correlation coefficient in the adjustment of the calibration curve of methylene blue, allots to consider that the molar extinction coefficient is constant in the investigated concentration range.

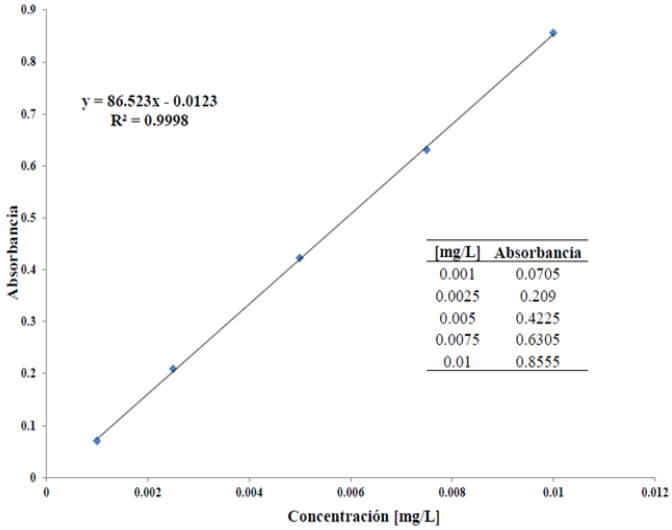

Fig 2. Calibration curve of methylene blue

Methylene blue index determines the mesoporous nature of activated carbon. The test allows to determine the capacity of the activated carbon to absorb large molecules like the colorants similar to methylene blue. Table 2 shows the results obtained from adsorbed absorbate in methylene blue and the percentage of activated carbon saturation in three concentrations of methylene blue (0.0025 mg L^{-1}, 0.075 mgL^{-1} and 0.01 mg L^{-1}).

Table 2: results of the absorption process of methylene blue in jacaranda activated carbon.

Time (minutes)	[0.0025]		[0.075]		[0.01]	
	Adsorbed absorbate (mg/g)	% adsorption	Adsorbed Absorbate (mg/g)	% Adsorption	Adsorbed Absorbate (mg/g)	% Adsorption
5	0.1093	48.08	0.3481	46.69	0.5180	51.80
10	0.1413	62.18	0.5043	67.64	0.5998	59.98
15	0.1447	63.65	0.5349	71.75	0.6552	65.52
20	0.1496	65.80	0.5920	79.41	0.7038	70.38
25	0.1515	66.65	0.6136	82.31	0.7439	74.39
30	0.1676	73.74	0.6261	83.98	0.7816	78.16
35	0.1690	74.36	0.6583	88.29	0.8043	80.43

Figure 3 shows that at low concentrations (0.0025mg L^{-1}) of methylene blue, affinity of carbon activated is null. However, at high concentrations (0.01 mg L^{-1}) an adsorption of methylene blue is obtained allowing a saturation as high as 80.43%.

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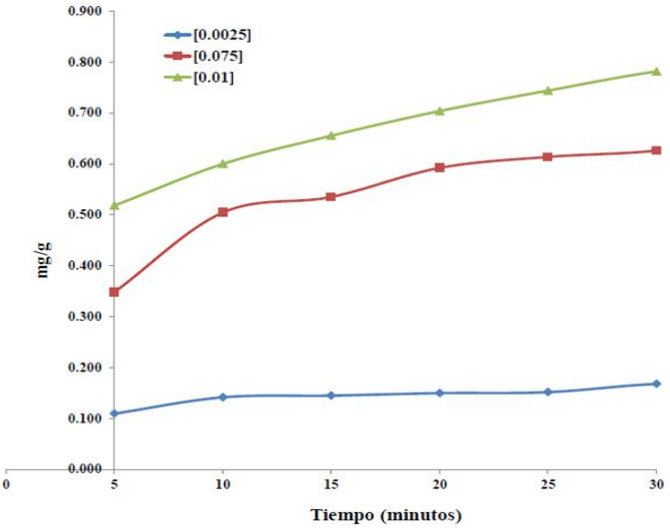

Fig 3: methylene blue adsorption in a range of 35 minutes at different concentrations.

Similar results have been described by several authors with precursors such as sugar cane bagasse, corn juice [11], and chestnut shell [16], coconut shell [6] and chemical activation with H_3PO_4 which indicate that when the carbonized was impregnated with phosphoric acid lignin hydrolysis was facilitated that was still present in the carbonized. Therefore, the capacity of the process was increased and porosity was developed [4]. This porosity can be attributed to the dehydrating nature of the phosphoric acid which promoted acid hydrolysis reactions [17].

C. Scanning Electron Microscope (SEM)

The morphologic study was performed by a Scanning Electron Microscopy on a Jeol computer model JSM-6300. The activated carbons were coated with a gold film to create the conducting sample. In the photomicrographs of the figure, two types of approaches 65x and 1000x were performed. Both photomicrographs show cavities with a high degree of roughness and uniformity. These spaces are on the order of 10µm. Similar results are reported in the eucalyptus stems [8] and coconut shell [6] where the use of phosphoric acid at low temperatures allows the raw/starting matter not to suffer a drastic structural alteration.

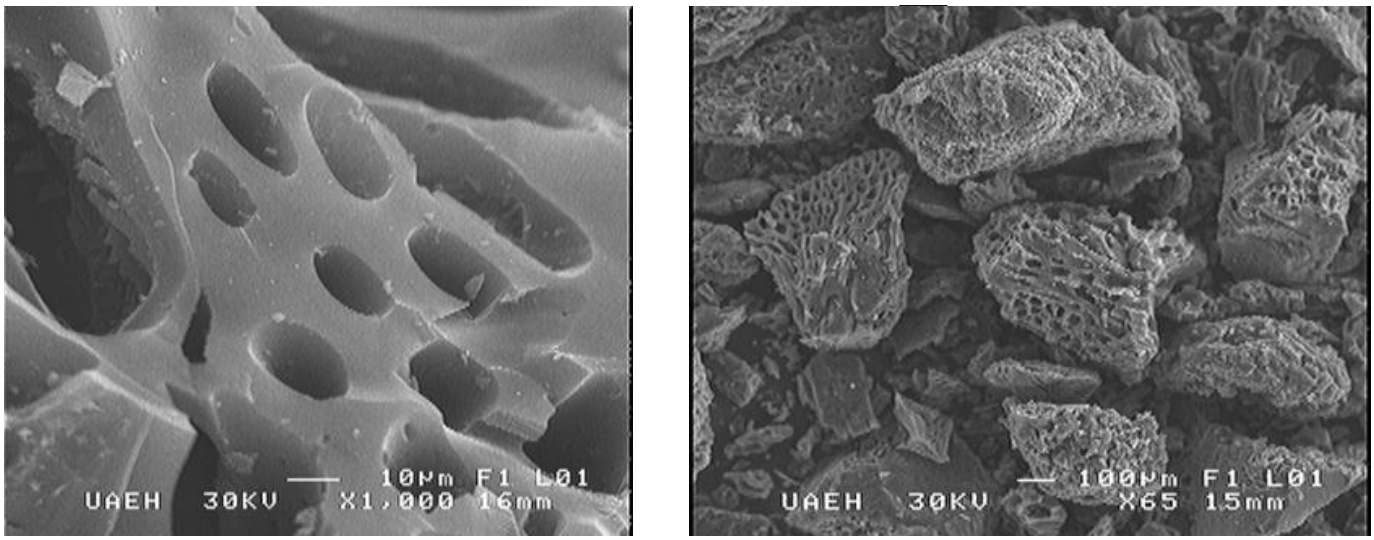

Fig 4: photomicrographs of activated carbon from jacaranda, a) X65 and b) X1000

IV. CONCLUSIONS

The use of H_3PO_4 as an impregnating agent is a good method for the preparation of activated carbon used as the precursor material of jacaranda fruit (Mimosifolia). The technique to evaluate the absorption process of methylene

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blue indicates the behavior of activated carbon which shows a surface concentration of more than 80%.

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