

Preparation and Characterization of Activated Carbons Based On Peanut Shell (*Arachis Hypogaea*) Green Soya Shell (*Vigna Radiata*)

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Abstract: Two activated carbons were prepared based on peanut shell (CAA) and green soya shell (CAS) at 500 °C during 6 h after impregnation in soda. Without impregnation in soda, two non-activated carbons were prepared in the same conditions, from peanut shell (CNAA) and green soya shell (CNAS). To compare, we characterized two commercial activated carbons. The first, CACOM 1, was bought in a drug store and the second, CACOM 2 was bought in a shop of chemical products. The ash content of all carbons was lower than 12 %, except CACOM 1 (42 %). The presence of excipients is certainly the reason of the high ash content of CACOM 1. The pH values of all carbons except CACOM 2 changed from 7.35 to 7.73. The pH value of CACOM 2 is 9.24. The determination of the specific surfaces of carbon was carried out according to the model of Langmuir with the molecule of acetic acid. The specific surfaces of CNAA, CNAS, CAA, CAS, CACOM 2 and CACOM 1 are respectively 141.47 m²/g, 194.46 m²/g, 311.15 m²/g, 433.09 m²/g, 514.32 m²/g and 1206,30 m²/g. The specific surfaces of CAA and CAS are closer than the commercial carbon CACOM 2.

Keywords: activated carbon, peanut shell, green soya shell, acetic acid, Langmuir.

1. Introduction

Medicinal poisoning is one of the most common medical emergencies in many countries [1]–[2]. It is the same case in our country, Côte d'Ivoire. For example, a study showed that from 1993 to 2013, in the “centre hospitalier universitaire (CHU)” of Yopougon (Abidjan), most of 60.5 % of the substances implicated for human poisoning were drugs [3].

There are many methods to treat poisoning, such as the use of specific antidote, emetics; gastric lavage, dilution and activated carbon [4]–[5]. Adsorption by activated carbon is an easy and reliable treatment, but it is costly.

The main aim of this study is to prepare cheapness carbons from peanut shell (*Arachis hypogaea*) and green soya shell (*Vigna radiata*) to treat medicinal poisoning. The study also aims to valorize agriculture wastes such as peanut shell and green soya shell.

Acetic acid was used as adsorbent because the knowledge of its molecule surface (21 Å²) allows characterizing studied coals [6]–[7]. Besides, it allows facilitating the manipulation because the adsorbed quantity can be determined by a simple acido-basic dosage.

2. Material and Methods

2.1 Preparation of carbons

The shells of peanut came from a market of Abidjan (Côte d'Ivoire). The shells of green soya used to prepare activated carbon came from Koun Fao, Côte d'Ivoire.

Experimental protocol is similar to the study of Gueu S. [8]. The shells were washed with water, dried at 105 °C during 12 hours and ground to obtain samples of 1-2 cm particle size. After that, the shells were mixed with NaOH (1N) during 24 hours and dried again at 105 °C during 12 hours.

Then, the shells were carbonized at 500 °C during 5 hours in an electric furnace (Advantec KL-280). The obtained carbons were cooled in a desiccator. After cooling, the samples were rinsed several times with distilled water until obtaining flushing water with pH ranging between 6 and 7.

The wet samples were dried at 105 °C during 12 hours. They were then crushed and filtered. Only particles ranging between 150 and 250 μm sizes were recovered. These carbons are called CAA (Carbon Activated from Arachis) and CAS (Carbon Activated from Soya).

Non-activated carbons were prepared in the same conditions without impregnation in soda. They are called CNAS (Carbon Non-Activated from Arachis) and CNAS (Carbon Non-Activated from Soya).

To compare the preparation of activated carbons, two commercial carbons were characterized. The first was bought in a drug store in Abidjan. It is a tablet named “Carbophos charbon végétal 400 mg”. We called it CACOM 1 in this study. The second is a powder carbon bought in a shop of chemical products in Abidjan. It is called CACOM 2 in this work but it was called CAPCOM in our previous study [9].

All used carbons were in powder or crushed into powder to obtain samples of 150 and 250 μm particle size.

2.2. Characterization of Carbons

2.2.1. Ash content

The carbons were burnt at 650 $^{\circ}\text{C}$ during 7 hours in an electric furnace [8]. The samples were weighted before and after calcination, the ash content (T_C) was calculated using equation 1:

$$T_C = \frac{m_1 - m_2}{m_1} \times 100 \quad (1)$$

Where m_1 and m_2 are the weights of samples before and after calcination respectively.

2.2.2. pH value

To determine the pH value, 1 g of carbon was added to 100 mL of distilled water and mixed during 24 hours. After filtration, the pH of filtrate was determined with a multi-parameter HANNA HI 9828. The pH of the reference solution was also measured. The reference solution was prepared by mixing 100 mL of distilled water without carbon addition during 24 hours.

2.2.3. Kinetic of adsorption: time of balance

The determination of time balance was done by mixing a mass of 0.25 g of carbon with a volume of 50 mL of solution of acetic acid of concentration C_o during variable times, in various flasks.

Flasks were shaken with an agitator (Vibramax 100 of Heidolph instruments). After different times: 5 min, 10 min, 15 min, 30 min, 45 min and 60 min, the mixture was filtered. A volume $V_a = 10$ mL of the filtrate was measured by a solution of soda of concentration C_b in the presence of some drops of phenolphthalein. The volume V_{eq} of the solution of soda is obtained at equivalence. The residual concentration C_r of acetic acid was calculated with the following formula:

$$C_b \times V_{eq} = C_r \times V_a \quad (2)$$

The time which the residual concentration C_r remains constant is the time of balance. This time will be used as time of contact for the study of the isotherms of adsorption.

2.2.4. Determination of isotherms adsorption

The isotherms of adsorption were determined following the same protocol of kinetic adsorption as described above. The concentration C_o was set at: 0.01 mol/L, 0.02 mol/L, 0.04 mol/L, 0.06 mol/L and 0.1 mol/L. About 0.25 g of carbon was put in every flask. Flasks were shaken with the agitator during the time of balance. The mixture was then filtered and measured by the solution of soda of concentration C_b . At the end of the dosage of the filtrate, the residual concentration C_r was calculated according to the equation 1 and the adsorbed quantity a was determined by the following formula:

$$a = \frac{C_o - C_r}{m} \times V \quad (3)$$

2.5. Model of Langmuir

Langmuir model is mathematically represented by the following equation:

$$a = \frac{a_m b C}{1 + b C} \quad (4)$$

The linear form of Langmuir equation is generally used:

$$\frac{1}{a} = \frac{1}{a_m} + \frac{1}{a_m b} \times \frac{1}{C} \quad (5)$$

Where b (without unit) is the thermodynamic constant of Langmuir linked to the adsorbing-adsorbent system, a (mol/g) the quantity of species adsorbed by one gram of solid and a_m (mol/g) the quantity of species adsorbed by one gram of solid necessary to cover the surface of the solid of a monomolecular coat. C (mol/L) represents the residual concentration of the liquid [10]–[11].

The graphic representation of $1/a$ in function of $1/C$ gives a straight line in the case where Langmuir model is applicable and allows calculating constants a_m and b [12]–[13].

Knowing a_m , the specific surface of adsorbent S_L is calculated with the following formula:

$$S_L = a_m \omega_m N_A \quad (6)$$

N_A and ω_m (m^2) respectively represent the number of Avogadro and the area occupied by a molecule of adsorbent [14].

3. Results and Discussion

3.1. Ash Content

The ash content is an important characteristic of carbon values greater than 20 % indicate insufficient carbonization. This means that carbon has a bad capacity of adsorption [15].

The ash contents of carbons are given in table 1.

Table 1: Ash content of carbons

Carbons	Weight before (g)	Weight after (g)	Ash content (%)
CNAA	1	0.96	4.00
CAA	1	0.97	3.00
CNAS	1	0.88	12.00
CAS	1	0.94	8.00
CACOM 1	1	0.79	42.00
CACOM 2	1	0.93	7.00

The ash content of all carbons is lower than 12 %, except CACOM 1, the carbon bought in a drug store. The presence of excipients is certainly the reason of the high ash content of CACOM 1.

The activation by soda reduces the ash content of the prepared carbons from 4 % (CNA A) to 3 % (CAA) and from 12 % (CNAS) to 8 % (CAS).

3.2. pH value

Table 2: pH value of carbons

Carbons	pH value
SAMPLE	6.14
CNA A	7.35
CAA	7.67
CNAS	7.44
CAS	7.73
CACOM 1	7.51
CACOM 2	9.24

An examination of the pH values (table 2) shows that the pH of the reference sample (distilled water) is 6.14, while the values of all carbons except CACOM 2 vary from 7.35 to 7.73. This means that carbons are slightly basic.

The pH of CACOM 2 is 9.24, which indicates that this carbon is basic. Therefore CACOM 2 can be a good adsorbent of acidic substance.

3.3. Kinetic of adsorption: time of balance

The determination of time of balance or contact time tells about the necessary time to reach the balance of adsorption (figure 1).

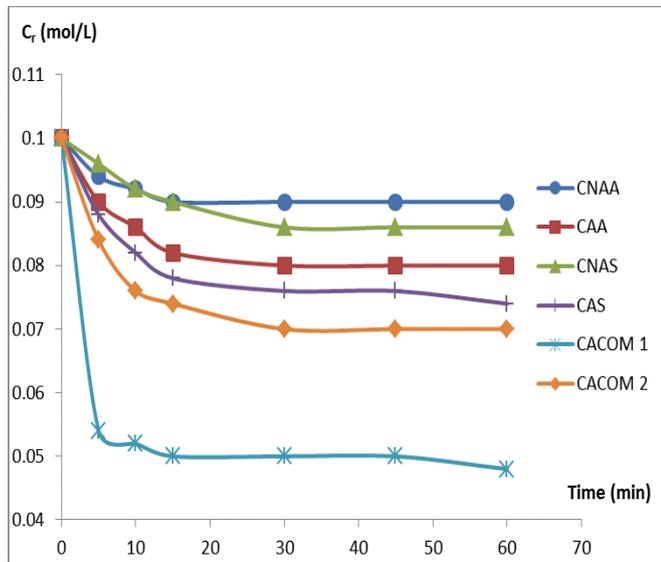


Figure 1: Time of balance of acetic acid adsorption on various carbons

We notice that after a time of contact of 30 minutes with various carbons, the residual concentration of the acetic acid remained almost constant. This result fits with the literature where the time of definite balance is often lower or equal to 30 minutes [16]–[17]. Thus, 30 minutes was used as time of balance for isotherms study.

3.4. Adsorption Isotherms

Figure 2 represents the isotherms of adsorption of the acetic acid on various coals of our study.

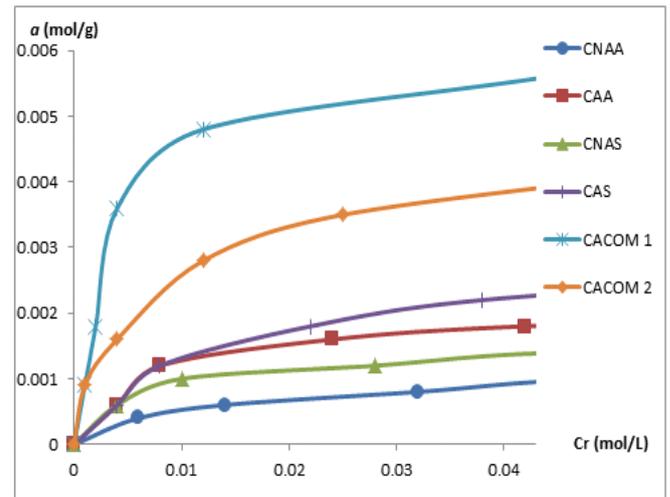


Figure 2: Adsorption isotherms of acetic acid on various carbons

The IUPAC classifies them in six categories. All the curves of the figure 2 are well similar to the isotherm of type I of this classification [18]–[19]. This type of isotherms is observed in the case of an adsorption in the microporous solids having pores of molecular dimensions (diameter lower than 2 nm). It is also observed in the case of an adsorption leading to the formation of a monocoat. These isotherms of adsorption can thus be described by the model of Langmuir.

3.5. Langmuir model's application

Figure 3 shows the linear representation of the isotherms of adsorption according to the model of Langmuir. Table 3 indicates that the coefficients of correlation (R^2) get closer to 1 (from 0.961 to 0.994). The adsorption of the acetic acid on all these carbons can be thus described by the model of Langmuir.

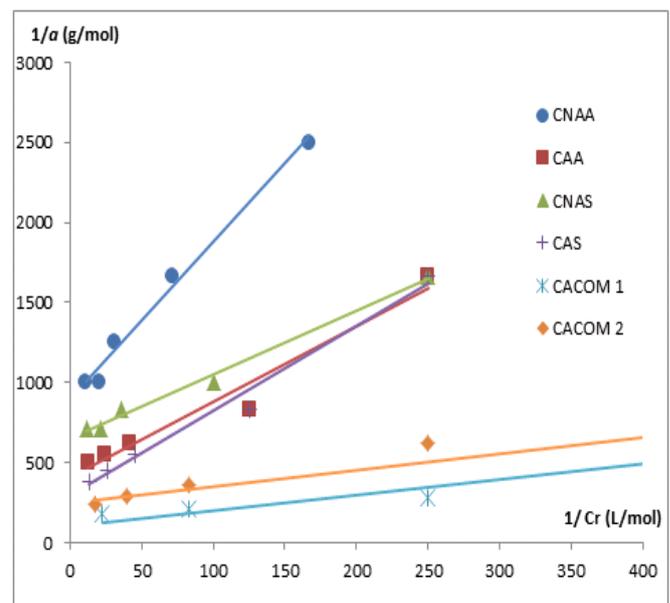


Figure 3: Langmuir model's application on various carbons

Table 3: Parameters of Langmuir model

Carbons	R ²	$a_m \times 10^4$ (mol/g)	b	S_L (m ² /g)
CNAA	0.989	11.19	91.06	147.47
CAA	0.961	24.61	85.65	311.15
CNAS	0.991	15.38	162.40	194.46
CAS	0.983	34.25	55.18	433.09
CACOM 1	0.982	95.42	107.71	1206.30
CACOM 2	0.994	40.68	450.86	514.32

The application of the model of Langmuir allows us to calculate the capacity of maximal adsorption a_m and the thermodynamic constant of Langmuir b .

A high coefficient a_m guarantees a good adsorption. The determination of a_m allowed us to calculate the specific surfaces S_L offered by every carbon which vary from 194.46 to 1206.30 m²/g.

The activation allowed to double the specific surface of activated carbons. Indeed, the specific surface of CNAA was 147.47 m²/g and 311.15 m²/g for CAA when the specific surface of CNAS was 194.46 m²/g and 433.09 m²/g for CAS. These results are in agreement with previous studies [20]–[21]. The capacity of adsorption of CAS is practically equal to CACOM 2. The rank order of decreasing value of S_L for different coals was:

CACOM 1 > CACOM 2 > CAS > CAA > CNAS > CNAA.

Our study showed that the soya shell is a better precursor than the peanut shell because the specific surface of CAS is higher than CAA although CAS and CAA were prepared in the same conditions.

4. Conclusion

The characterization of the activated carbons prepared from peanut shell (CAA) and green soya shell (CAS) were carried out.

The pH values of CAA and CAS are respectively 7.67 and 7.73, indicating that these carbons are slightly basic. The ash contents of CAA and CAS are respectively 3 % and 8 %. These are good value because they are lower than 20 %.

The determination of the specific surfaces of carbon was carried out according to the model of Langmuir with the molecule of acetic acid. The specific surfaces of CAA and CAS are respectively 311.15 m²/g and 433.09 m²/g. These are closer to the specific surface of the commercial carbon CACOM 2 which is 514.32 m²/g.

The activated carbon prepared in this study can be used for adsorption in general and for treatment of medicinal poisoning.

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