

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).

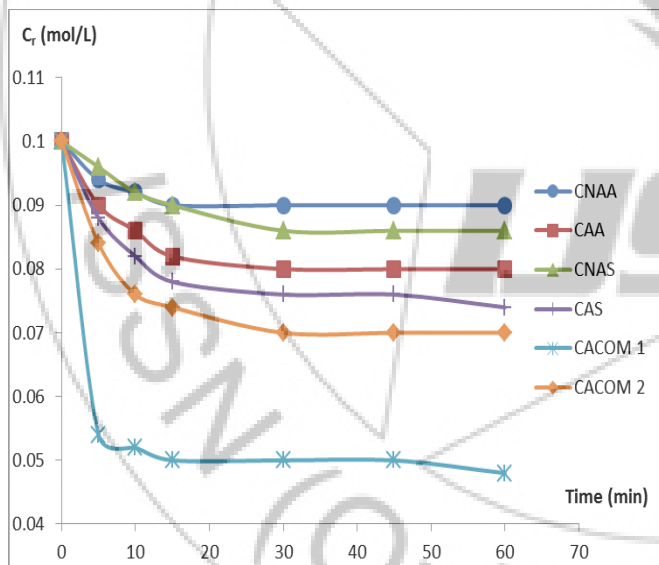


Figure 1: Time of balance of acetic acid adsorption on various carbons

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.

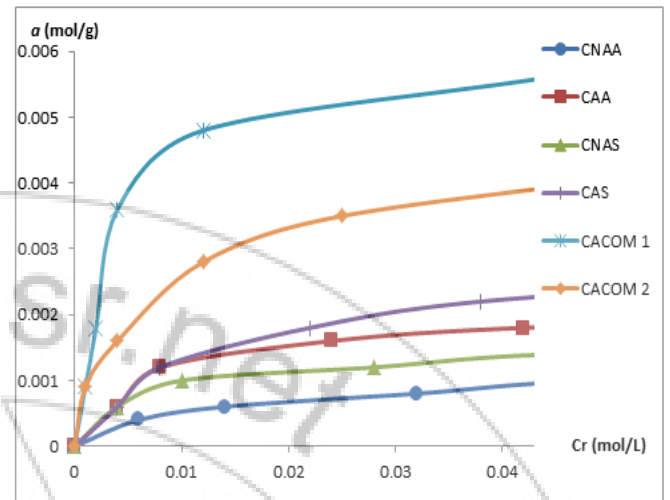


Figure 2: Adsorption isotherms of acetic acid on various carbons

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.

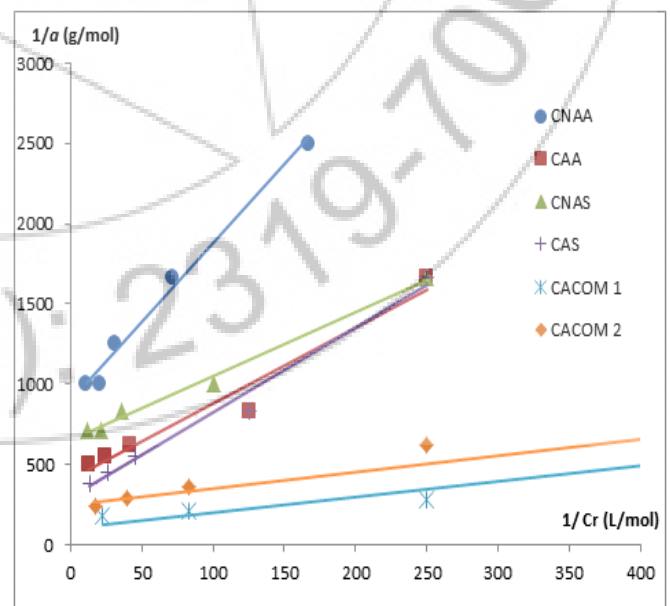


Figure 3: Langmuir model's application on various carbons

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.

References

- [1] K. Chakrabarti, K. C. Devkota, "Retrospective study of suicide cases admitted in Nepal Medical College Teaching Hospital," Nepal Med. Coll. J., 6, pp. 116-118, 2004.
- [2] J. Bernard, "Situation du surdosage antalgique en automédication en France en 2009," Thèse de Doctorat, Université de Paris 7 – Denis Diderot, pp. 4-67, 2010.
- [3] T. Yéo, J. C. Babo, J. Kohy, K. Edmond, N. Ackoundoun, A. Amonkou, "Prise en charge des intoxications aiguës au CHU de Yopougon," Afrique biomédicale, 13 (2), pp. 14-21, 2008.
- [4] F. Roulas, M. Sorkine, "Intoxications médicamenteuses. Intoxications aiguës: diagnostic et prise en charge," Masson, Paris, pp. 33-8, 1990.
- [5] E. Roupie, L. Leionc, "Épuration digestive au cours des intoxications aiguës: six ans après un consensus," Médecine et Hygiène, 56, pp. 1511-1513, 1998.
- [6] J. Avom, M. J. Ketcha, M. R. Matip, P. Germain, "Adsorption isotherme de l'acide acétique par des charbons d'origine végétale," African Journal of Science and Technology (AJST), Science and Engineering Series, 2 (2), pp. 1-7, 2001.
- [7] I. M. Gouli Bi, A. J. Yapo, S. A. Ello, D. Diabaté, A. Trokourey, "Adsorption of acetic and benzoic acids from aqueous solutions on activated carbon," J. Soc. Ouest-Afr. Chim., 26, pp. 53-57, 2008.
- [8] S. Gueu, "Traitement de la pollution métallique et organique par les charbons actifs des coques de noix de coco et des graines de palmistes," Thèse de Doctorat, Université de Cocody-Abidjan, pp. 5-20, 2007.
- [9] K. Ouattara, M. Gouli, S. Ello, A. Yapo, A. Trokourey, "Adsorption of acetic acid on different carbons," International Journal of Engineering Science and Technology (IJEST), 4 (10), pp. 4398-4403, 2012.
- [10] A. S. Mohammed, "Modélisation de l'adsorption par les charbons microporeux: Approches théorique et expérimentale," Thèse de doctorat, Université de Neuchâtel, Neuchâtel, pp. 1-40, 2002.
- [11] B. E. Reed, M. R. Matsumoto, "Modeling cadmium adsorption by Activated carbon using Langmuir and Freundlich isotherm expressions," Sep. Sci. and techn., 28, pp. 2179-2195, 1993.
- [12] E. Pehlivan, B. H. Yanik, G. Ahmetli, M. Pehlivan, "Equilibrium isotherm studies for the uptake of cadmium and lead ions onto sugar beet pulp," Bioresource Technol., 99, pp. 3520-3527, 2008.
- [13] I. Kenichiro, K. Kawamoto, "Fundamental adsorption characteristics of carbonaceous adsorbents for 1, 2, 3, 4-tetrachlorobenzene in a model gas of an incineration plant," Environ. Sci. and Technology, 39, pp. 5844-5850, 2005.
- [14] M. KIA, W. M. Kifuani, V. Mukana, V. Noki, "Adsorption de bleu de méthylène en solution aqueuse sur charbon actif obtenu à partir des sciures végétales. Préparation et caractérisation du charbon actif," Rev. Cong. Sci. Nucl. 20 (1/2), pp. 215-224, 2004.

- [15] C. Ayrat, "Elimination de polluants aromatiques par oxydation catalytique sur charbon actif," Thèse de Doctorat, Université de Toulouse, pp. 68-74, 2009.
- [16] F. Fiesseinger, "Progrès récents dans l'utilisation de charbon actif pour le traitement des eaux potables," L'eau et l'industrie, 53, pp. 23-33, 1981.
- [17] M. J. Iqbal, M. N. Ashiq, "Adsorption of dyes of aqueous solutions on activated charcoal," Journal Hazardous Materials, B, 139, pp. 57-66, 2007.
- [18] L. Khezami, R. Capart, "Removal of chromium (VI) from aqueous solution by activated carbons: Kinetic and equilibrium studies," J. Hazard. Mater. B, 123, pp. 223-231, 2005.
- [19] G. Mackay, M. S. Bino, A. R. Altamemi, "the adsorption of various pollutants from aqueous solutions onto activated carbon" Wat. Res. 19, pp. 491-495, 1985.
- [20] C. Moreno-Castilla, F. Carasco-Martin, M. V. Lopez-Ramon, M. A. Alvarez-Merino, "Chemical and physical activation of olive-mill waste water to produce activated carbons," Carbon, 39, pp. 1415-1420, 2001.
- [21] I. A. Rahman, B. Saad, "Utilization of guava source of activated carbon for removal of methylene blue from aqueous solution," Malaysian journal of chemistry, 5 (1), pp. 8-14, 2003.

Authors Profile

P. H. K. Ouattara, M.Sc., student in physical chemistry, University of Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

M. I. Gouli Bi, Ph.D. in chemistry, Lecturer in Laboratoire de Chimie Physique, University of Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

U. Kouakou, M.Sc., student in physical chemistry, University of Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

A. Dembélé, Ph.D. in chemistry, Chief executive of Laboratoire National pour l'Appui au Développement Agricole (LANADA), Abidjan, Côte d'Ivoire

A. Yapo, Ph.D. in chemistry, Researcher in Laboratoire de Chimie Physique, University of Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

A. Trokourey, Ph.D. in chemistry, Professor, Chief of Laboratoire de Chimie Physique, University of Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire