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Composite Material Polystyrene Activated Carbon for Water Purification

F Z. Lakhal[1], A. Maghchiche[2], R. Nasri[3], A. Haouam[3]

1. *Université de Tébessa, institut des sciences exactes et sciences de la nature et de la vie département des sciences de la matière Tébessa 12000 -Algeria.*
2. *Département de pharmacie, faculté de médecine, université Batna 2 - Algeria.*
3. *Laboratoire Pollution et Traitement des Eaux, département de chimie, faculté des sciences de la matière, université Constantine 1. Route Ain-el-Bey 25000, Constantine- Algeria.*

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amaghchiche@yahoo.fr
Phone: +213553278363

Abstract

The use of activated carbon as an organic adsorbent material have many regeneration problems. The most recent research works tend to combine activated carbon with some other material possessing original physical properties in order to obtain multifunctional composite materials. Our work consists in the design of a unique multifunctional process, for fine and hyper fine separation and improvement of the adsorption and discoloration of polluted solutions in the presence of composite material. The results we obtained suggest the development of an economic and effective water purification system.

1. Introduction

The area which has attracted the attention of researchers for decades and which was the subject of our work was the treatment of the polluted solutions with a simple and effective technique. The classic treatment of wastewater is done in several separate steps, which are the filtration, coagulation, flocculation, coal degasification, discoloration and finally the elimination of ions (anions and cations) which are not desirable.

All this work is long, tedious and costly. The goal of this work was to reduce the maximum steps listed previously, by the design of a single device which will be the subject of a waste water treatment plant, miniaturized fixed or mobile.

Basically, the composite materials should fulfill different types of treatment, differing by their constitution and their respective intended uses [1-5]. Polymer nanocomposites have attracted the attention of scientists and technologists in water purification due to improved processability, surface area, stability, tunable properties, and cost effectiveness [6].

At first, the purification process was applied to solutions containingfine particles in suspension. The second category of solutions to which our process was applied were clear stained solutions. Their treatment is interesting in many areas, from domestic use to nuclear application in nuclear plants for water treatment by application of weakly carboxylic acid cation exchange resin [7].

The subject of our work was the purification of solutions intended for domestic use (surface water or groundwater) or wastewater, the composite material, according to the standard ISO 472 by definition, was a solid product, or semi solid(gel) containing at least two distinct phases: a material matrix and a material in particulate form or fibrous.

The composite system was a system consisting of several components put in contact to obtain the advantage of each element without they react between them. Inert supports are the fibers in braided glass, synthetic fibers (plastic, carbon). Active carriers are: active coal of animal or vegetal origin in particle form, activated carbon is a non-specific adsorbent with a well-developed porous structure formed mainly by microporous and mesoporous of different diameters, active carbon was defined as highly porous carbonaceous material which have a large surface area of high porosity and hence its adsorption properties are exceptional [8-11].

Synthetic colorantshave the reputation of being persistent toxic substances at the environment require modern physical-chemical techniques for their degradation [12-15].Adsorption is a surface phenomenon, hence the interest in knowledge of physical properties of adsorbent materials such as porosity, surface area, apparent and real density [16-19].

2. Material and Methods

2.1. Materials

1. Reinforcement

The activated carbon used in this study was a commercial product supplied by (E. Merck, Darmstadt), in grain and powder form of plant origin. Before its use the carbon was put in an oven at 120°C for 24 hours.

2. Methyl orange Dye

Methyl orange (MO) was used as a model organic pollutant. MO has an aromatic polycyclic structure, with a formula $C_{14}H_{14}N_3O_3S^-Na^+$, showing a negative charge at one end.

3. Polystyrene Matrix

Polystyrene used was obtained by radical polymerization of styrene in the presence of the catalyst $C_{14}H_6O_4$ at 60 °C [20,21].

4. Preparation of the composite material (Polystyrene-activated carbon)

A polystyrene-active carbon composite material was prepared by combining the properties of polystyrene with the large specific surface area of activated carbon:

2 g of polystyrene was dissolved in 50 ml of toluene with continuous stirring and 10 g of powder activated carbon were added to the polymer solution with stirring for 30 minutes.

The mixture is spread at cartridge WPP105M surface for 48 hours to obtain a cartridge covered with composite material then placed inside the experimental device equipped with an inlet of the polluted solution and a decontaminated solution outlet after passing through the composite material of the cartridge.

2.2. Experimental setup

The device used in the experiments was a water filtration apparatus(Figure 1) equipped with a cartridge filter WPP105M type of 5 microns (Figure 2) covered with polypropylene fiber. The device was provided with an inlet and an outlet.

Figure 1:Filtration equipment

Figure 2: Cartridge, type WPP105M

The operating mode for the adsorption of impurities on the activated carbon comprises a following steps:
- Preparation of the acidic solution and the colored solution.
- Putting into contact of a precise volume of solution with a precise mass of adsorbent.
- Stirring the reaction mixture for 30 minutes.
- Separation of solid and liquid phases by filtration with filter paper.
- Analysis of the filtrate by measuring the pH (in the case of HCl) or the Absorbance (in the case of MO)
- Adsorption tests were carried out in 50 ml beaker at ambient temperature (22°C).

for all experiments, it was repeated three times and the mean of each experiment was calculated.

2.3. Adsorption tests:

2.3.1. Adsorption Discoloration Tests

- Preparation of 100 ml solution of dye, (0.01 % in distilled water)
- Addition of a 50 g portion of activated carbon.
-Contact time of 30 minutes with constant stirring
-Filtration on ordinary filter paper.

50 g of activated Carbon was used with 3 drops of MO in 100 ml water solution of water, the solution becomes transparent.

2.3.2. Adsorption of HCl on Activated carbon

Adsorption experiments were carried out under the following operating conditions:

- Mass of carbon grains in cartridge: 60.75 g.
- solution of HCl acid was prepared by: 1 ml of solution of HCl (1N) was added to 2 liters of distilled water, the contact time was set at 15 minutes at ambient temperature (25 °C).
- pH of prepared solution (5.10^{-4}M) at t = 0 min, pH = 3.62; the results are as followsin(Table 1) and (Figure 3):

Table 1: Adsorption of HCl on Activated Carbon

$V_{recovered}$ (30ml)	$V_{sample\ 1}$	$V_{sample\ 2}$	$V_{sample\ 3}$	$V_{sample\ 4}$	$V_{sample\ 5}$
Time (min)	3	6	9	12	15
pH	3.84	5.13	5.70	5.29	4.70

2.3.3. Effect of the polystyrene-activated carbon composite material on HCl removal

The adsorption experiments were carried out under the following operating conditions:

-Preparation of (acid + water) solution.
-The solution (acid + water) flows from the 500 ml separating funnel into the filtration apparatus where it passes through the cartridge covered with the appropriate adsorbing material.
-Recovery of the solution from the outlet tap.
-Analysis of the solution recovered by PH metric.

the results are as shown in (Table 2) and (Figure 4):

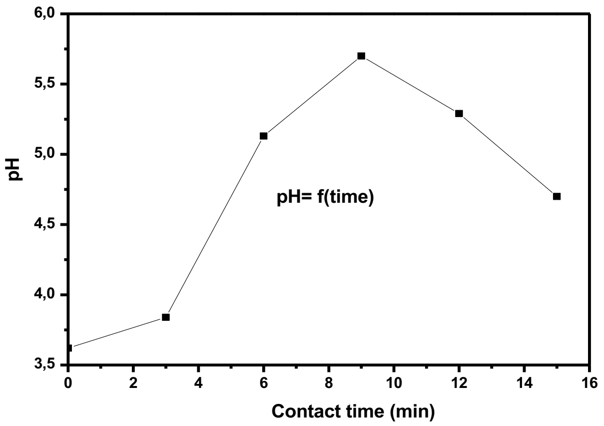

Figure 3: Acid removal by adsorption on pure activated carbon: pH = f (contact time)

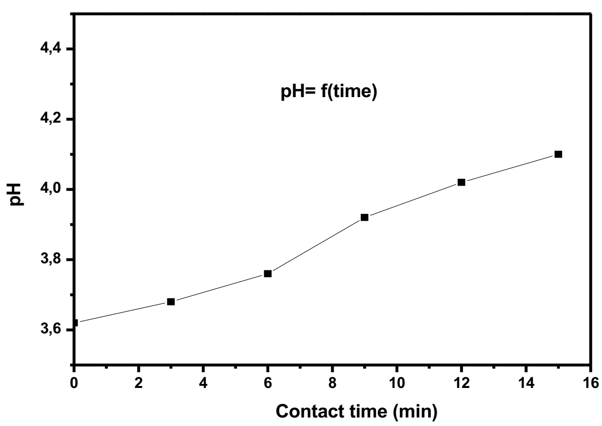

Figure 4: Efficiency of the polystyrene-activated carbon composite material on the removal of HCl; pH = f (contact time)

Table 2: Effect of polystyrene-activated carbon composite material on removal of HCl

V recovered (30ml)	V sample 1	V sample 2	V sample 3	V sample 4	V sample 5
Time (min)	3	6	9	12	15
pH	3.68	3.76	3.92	4.02	4.10

2.3.4. Adsorption of methyl orange on activated carbon

The activated carbon used for the removal of methyl orange in aqueous solution. The operating conditions are as follows:
- Mass of activated carbongrain in cartridge 60.75g.
- 42 drops of methyl orange (0.01N) in 2 liters of distilled water, contact time 15mn at ambient temperature 25°C
- Characteristic of the initial colored solution at t = 0 min: pH = 6.78, A = 0.78.

The results are as follows in (Table 3) and(Figures 5&6) :

Table3: Adsorption of methyl orange on activated carbon

$V_{recovered}$ (30ml)	$V_{sample\ 1}$	$V_{sample\ 2}$	$V_{sample\ 3}$	$V_{sample\ 4}$	$V_{sample\ 5}$
Time (min)	3	6	9	12	15
pH	6.82	6.85	7.17	7.15	6.88
Absorbance (A)	0.761	0.734	0.690	0.681	0.716

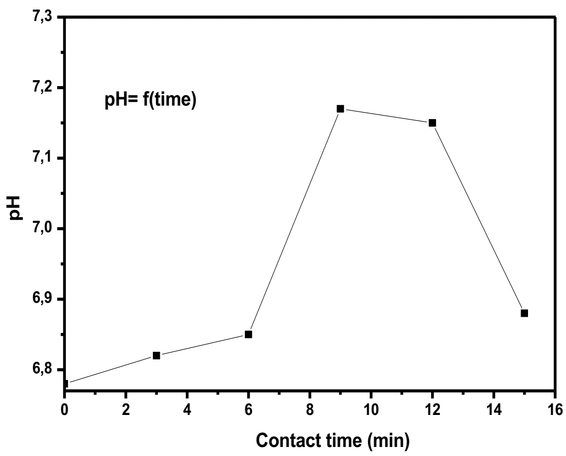

Fig. 5: MO Adsorption on activated carbon

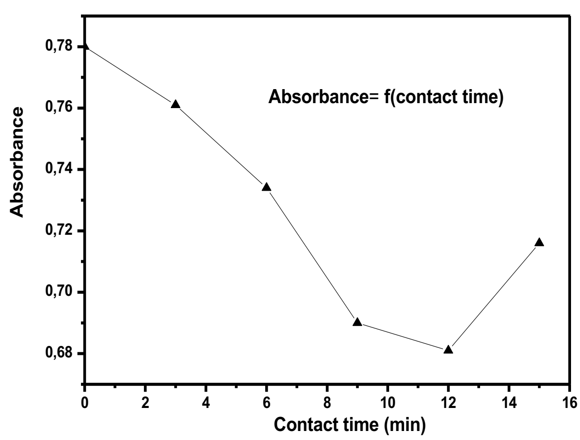

Fig. 6: Decolorization by activated carbon: Absorbance = f (contact time)

2.3.5. Effect of the composite material on discoloration of solution
The adsorption experiments were carried out under the same conditions used for the activated Carbon.
- PH of the colored solution at t = 0 min 6.30 and absorbance A = 0.824
- Solution of (methyl orange + water) flows from the bulb to the filtration unit where it passes through the covered cartridge of the composite material, the solution was recovered by the tap.

Analysis of the recovered solution was made by pH-metry, and UV-Visible spectrophotometry
the results are shown in (Table 4) and (Figures 7&8):

Table 4: Effect of polystyrene-activated carbon composite on discoloration

$V_{recovered}$ (30ml)	$V_{sample\ 1}$	$V_{sample\ 2}$	$V_{sample\ 3}$	$V_{sample\ 4}$	$V_{sample\ 5}$
Time (min)	3	6	9	12	15
PH	6.54	6.59	6.65	6.80	6.57
Absorbance (A)	0.555	0.340	0.331	0.331	0.385

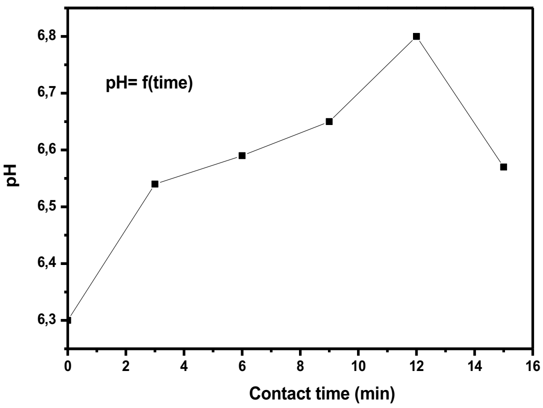

Figure 7: Acid removal by polystyrene-activated carbon composite: pH = (contact time)

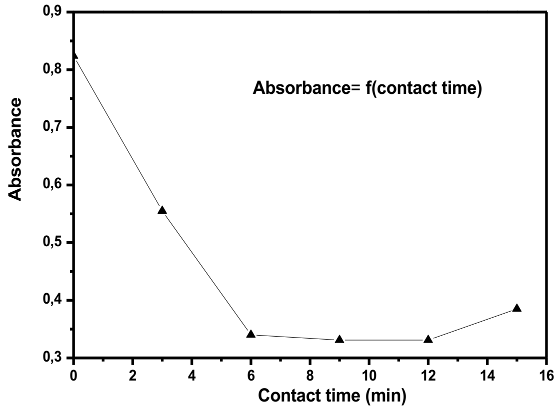

Figure 8: Discoloration by polystyrene-activated Carbon composite: Absorbance = f (contact time)

3. Results and discussion

The composite material adsorbs much larger amounts of dye than activated carbon. The improvement of the properties of the activated carbon results from the adjuction of the polymer and the impact on elimination of pollutants is considerable.

3.1. Spectral analysis of composite material

A spectrometer (SHIMADZU) FTIR-8201PC was used for infrared analysis(Figure 9). The composite material is finely ground and sieved and then mixed with KBr (1/300 by weight) [22]. Different bands were observed: A band at 3417.6 cm^{-1} assigned to the O-H bond, a band at 1388.7 cm^{-1} due to the vibration of C-O and another band at 1049.2 cm^{-1} is a distinguishing characteristic of the aromatic skeleton of polystyrene.

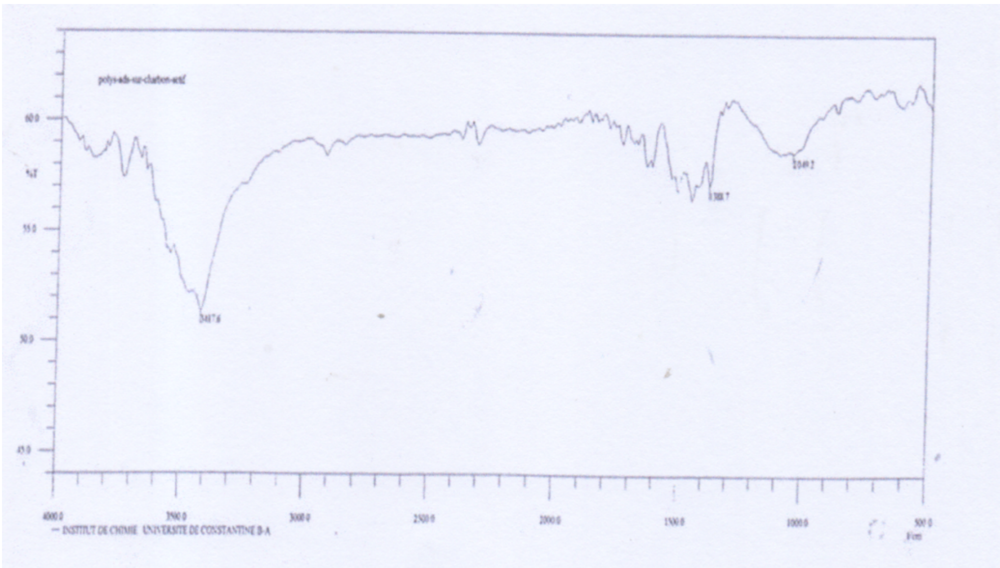

Figure 9: IR Absorbance variation of composite material

3.2. Effect of composite material on the decolorization orange methyl dye and the removal of the acid

Experiments on decolorization of methyl orange and HCl adsorption by the composite material were carried out. A comparative study between the active carbon / polystyrene composite material and activated carbon was done. (Table 5) and (Table 6) shows the absorbance and the pH of the solutions treated with carbon and composite material, respectively.

(Figure 10) and (Figure 11) show the variation of the absorbance and the pH as a function of time for composite material and activated carbon.

Table 5: Absorbance of solutions treated with active carbon and composite material at λ =460 nm

		Active carbon	Composite material
Absorbance	t=0 min	0.78	0.824
	t=3 min	0.761	0.555
	t=6 min	0.734	0.340
	t=9 min	0.690	0.331
	t=12 min	0.681	0.331
	t=15 min	0.716	0.385

The active carbon / polystyrene composite material adsorbs an amount of methyl orange much higher than the activated carbon, a rapid Absorbance fall is observed between 0-6 min in Figure 10. This is due to the increase of the adsorption properties of the adsorbent and synthesized polymer.

Table 6: Comparison of pH of adsorption at activated carbon and composite material

		Active carbon	Composite material
pH	t=0 min	3.62	3.60
	t=3 min	3.84	3.68
	t=6 min	5.13	3.7
	t=9 min	5.70	3.92
	t=12 min	5.29	4.02
	t=15 min	4.70	4.10

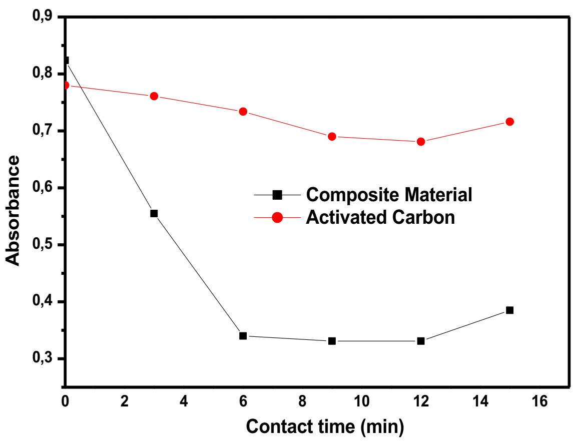

Figure 10: Absorbance variation of composite material and activated carbon

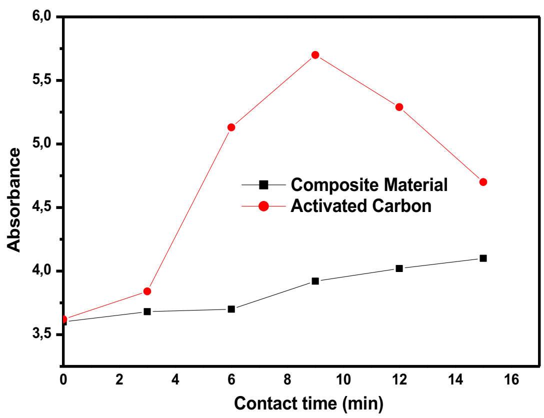

Figure 11: Variation of pH versus Time for composite and Activated Carbon

Conclusion

To guarantee the availability of clean water for humans into the future, efficient and cost-effective water purification technology will be required. The various adsorptive processes studied have advantages and disadvantages. Those which put different types of adsorbent in the same device are studied in such a way as to compensate for the limitations of use and the cost of conventional ones.

A composite system was produced combining the properties of polystyrene with the large specific Surface of activated carbon. Polystyrene was used as the binder of the matrix in the composition of this composite process. This matrix may have adsorption sites effective towards the targeted substances,

The simultaneous removal of organic, inorganic, and microbial contaminants from water by one material offers significant advantages when fast, facile, and robust water purification is required.

References

1.S. Herrmann, L. De Matteis, J. M .de la Fuente, S. G. Mitchell, & C. Streb., *Angew. Chem., Int. Ed.* 56-6 (2017) 1667-1670.
2.Y. Zhang, A. Mazumder, T. C. Zhang & C. Dai, *J. Chem.,* (2015) 2015
3. M.J. Sweetman, S. May, N.Mebberson, P. Pendleton, K. Vasilev, S. E. Plush & J. D. Hayball, *Carbon. C, 3*(2), 18. (2017)
4.A. Gonzalez-Perez & K. M. Persson, *Materials*., 2016,9(6) 447.
5. A. Z. Aroguz, V. Teofilović, S. Karademir, L. Tanasić, S. Aydogan, N. Vukić, & J. Budinski-Simendić, *Contep. Mater*.,1.7 (2017) 83-88.
6. N. Pandey, S. K. Shukla & N. B. Singh, *Nanocomposites.*, (2017). *3*(2) 47-66
7. M. Matsuda, K. Funabashi, F. Kawamura, S. Uchida & K. Ohsumi, *NT.*, (1987),*78*(1) 62-68.
8.R. C. Bansal, M. Goyal. Activated carbon adsorption. *CRC press.* (2005).
9. V. Bernal, A. Erto, L. Giraldo and J. C. Moreno-Piraján., *Molecules.,* 22.7 (2017) 1032.
10. Y. Zhang, F. Yu, W. Cheng, J. Wang, & J. Ma., *J. Chem.,* 2017 (2017).
11. J. Shu, S. Cheng, H. Xia, L. Zhang, J. Peng, C. Li& S. Zhang., *Rsc Adv*.,7.24 (2017) 14395-14405.
12. M. Yusuf, M. Shabbir& F. Mohammad, Nat. Prod., *Bio prospect.,*(2017)7-123.
13. B. S. Padhi, Int*., J. Environ. Sci.,*3.3 (2012) 940.
14. S. Mondal, M. K. Purkait& S. De, Advances in Dye Removal Technologies (2017).
15. K. Sharma, A. K. Dalai& R. K. Vyas, *Rev. ChemEng*.,34(1), (2017) 107-134.
16.F. Emmanuel. Thèse de doctorat Ecole Nationale Supérieure des Mines de Saint-Etienne, France (2000).
17.VV. Panić, SI. Šešlija, AR. Nešić, SJ. Veličković., *Hem Ind.,*67.6 (2013) 881-900.
18. S. D. Faust & O. M. Aly, *Adsorption processes for water treatment.*, *Elsevier* (2013).
19. O. G. Apul, N. H. von Reitzenstein, J. Schoepf, D. Ladner, K. D. Hristovski& P. Westerhoff., *Sci. Total Environ.,* 592 (2017) 458-464.
20. A. Maghchiche, A. Haouam, B. Immirzi., *J. Taibah. Univ. Sci.,*4 (2010) 9-16.
21. B .Michael, A. M.Van Herk , Radical Polymerization: Kinetics and Mechanism.,*John Wiley& Sons*(2007).
22. M. L. Sekirifa. Thèse de doctorat Univ Badji Mokhtar Annaba, Algérie (2013).

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