Regeneration of Activated Carbon Sutured Hexavalent Chrome

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Abstract: In order to prevent a simple pollution transfer and for the purpose of valorization of the process of activated carbon treatment, this one, saturated with pollutants should not increase the pollution mass of household waste. Indeed, an adsorbent offers a real interest only if it can be easily regenerated. This work addresses to the becoming the activated carbon after being saturation with hexavalent chromium. The activated carbon should not be stored directly, since the acid rain waters might leach some heavy metals. This would contaminate the soil and water resources. For this, it should be treated after use and returned to its original structure and chemical composition for an eventual future use with a good yield of re-adsorption. Within this work, the use of a base (KOH) has recovered an amount of hexavalent chromium retained by the activated carbon CAB. This one, regenerated was again used to secure the hexavalent chromium ions during several cycles. Regeneration test results have shown that the efficacy of CAB remains almost constant during the first four cycles of reuse and then decreases during the fifth cycle.

Keywords: Activated carbon, chromium VI, regeneration, recycling.

1. INTRODUCTION

In order to prevent a simple pollution transfer and for the purpose of valorization of the process of activated carbon treatment, this one, saturated with pollutants should not increase the pollution mass of household waste.

Most prior work relating to the regeneration study on organic materials, the essential element used as regenerating is H_3O^+ ion. Thus, Garg [1] studied the removal of chromium (VI) by Indian red wood sawyers treated with sulfuric acid. The recovery of chromium (VI) is done by simply washing with the mixture (NaOH, HCl). Muzzarelli [2] exploited the chitin to recover heavy metals from seawater. These metals are then recovered by an appropriate washing with acid. Haung [3] studied the regeneration of fungi biomass charged by Cd^{2+}. It was found that these materials can be regenerated by strong acids. Hoshi [4] exploited the chitin in the determination of copper adsorption-elution on column. Cu^{2+} retained was eluted by a mixture of acetic acid and acetone. Roy [8] showed that most of the heavy metals can be recovered by decreasing the pH of the medium, using an acid wash.

This work is devoted to the future of activated carbon after its saturation with hexavalent chromium. Indeed, the activated carbon can't be stored directly, since the acid water rains might leach some of the heavy metals attached, that would contaminate the soil and water resources. In order to avoid the displacement of pollution, the activated carbon used for decontamination of industrial effluents should be treated after use. Some methods are feasible:

- The elution: it provides a concentrated solution of low volume, suitable for precipitation processes for the possible recycling of heavy metal compounds and substrate reuse.
- The incineration: it generates ashes enriched on metal oxides. These ashes can be recycled if heavy metal content is appropriate to specifications of metallurgy units, or disposed in landfill site after treatment. Given its low volume, the cost of storage is reduced.
- The pyrolysis: it produces residues that contain heavy metals and carbon materials. These residues are also recyclable in secondary metal production, or disposed in landfill site after treatment.

One of these methods may be selected as an appropriate treatment of waste saturated with heavy metals, according to various criteria: the physical and chemical characteristics of the elements or their compounds, their economic value, etc. The biodegradation of these waste substrates is an alternative treatment at the end of life cycle.

Indeed, an adsorbent offers a real interest only if it can be easily regenerated. The activated carbon used in the retention of pollutants must regain its original structure and chemical composition of departure for future use with appreciable yield of re-adsorption.

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Considering all the work related to this issue, we opted for the following of this work to the valorization of activated carbon by the study of its regeneration by elution with a basic solution NaOH or KOH.

2. MATERIALS AND METHODS

2.1. Products Used

Potassium dichromate $K_2Cr_2O_7$, sodium hydroxide (NaOH), the diphenylcarbazide acid is prepared from the acid 1,5-diphenylcarbazide 97%, ethanol 95%, potassium hydroxide (KOH) and the sulfuric acid 95% of analytical grade are used in this study.

2.2. Experimental Protocol

The study of regeneration of hexavalent chromium fixed to CAB was performed using the device in agitated bath according to the following experimental protocol:

0.3 g of CAB saturated with Cr(VI) + 50 mL KOH or NaOH (0.5 M).

↓

Agitation 3 hours at T = 20 ± 2 °C.

↓

Filtering the mixture.

↓

Analysis of the concentration of Cr (VI) in the filtrate.

Schematic of the experimental protocol for regeneration of activated carbon.

3. RESULTS AND DISCUSSION

3.1. Regeneration of Active Carbon

3.1.1. Study of the Release of Cr(VI) Ions

After the regeneration test, we measured the concentration of the hexavalent chromium ion released for each of the bases NaOH and KOH used [6]. The results are summarized in Figure **1**.

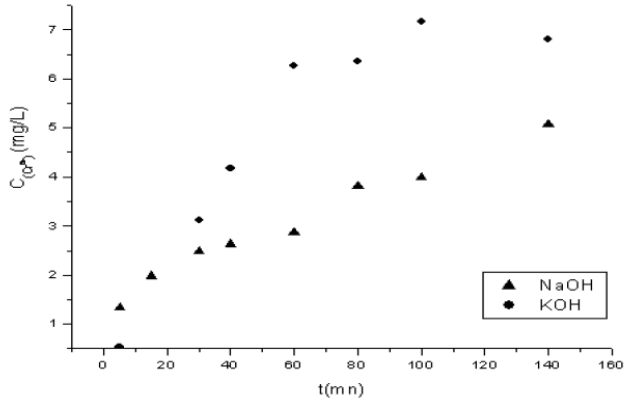

Figure 1: Variation of the concentration of released Cr(VI) ions as function of time. m_{ads} = 0.3 g, C_0 = 0 mg/L V = 50 mL et $v_{agitation}$ = 150 Tr/min.

The two curves show that the concentration of chromium Cr(VI) ions released increases with time [6]. This concentration reaches a maximum of 7.17 mg/L after 100 min of stirring in a solution of KOH base. However, it reached a value of 4.00 mg/L after 100 min of stirring in a solution of NaOH base.

According to these results, it is found that there is a releasing of ion Cr(VI) by the addition of Na^+ or K^+. The release increases with time to reach 5.07 mg/L in the case of 11.5 g/L of Na^+ and 6.80 mg/L in the case of 19.5 g/L of K^+. During the regeneration, the amount of K^+ set by the loaded activated carbon by Cr(VI) is greater than the amount of Na^+ set by this latter. As follows, we will use the base KOH for regeneration.

3.1.2. Displacement of Ions Cr(VI) by K^+ Cations

Desorption can regenerate chromium adsorbed onto activated carbon. It takes place in a basic solution of KOH with different concentrations 0.5, 1, 1.5 and 2 M. The results given in Figure **2a** shows that the released amount of Cr(VI) increases with time for each

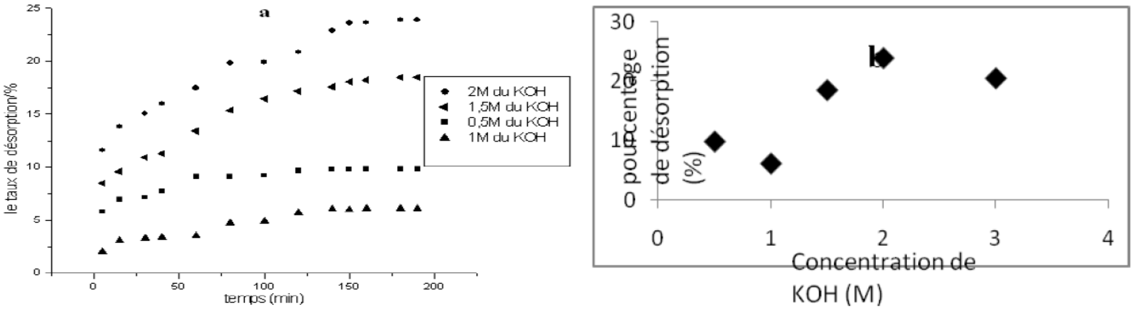

Figure 2: Study of the desorption of Cr(VI) as a function of a: the desorption rate as a function of the K + concentration and agitation time; b: desorption rate as a function of the K + concentration. mads = 0.9 g, h t = 3, V = 150 mL and v = 150 r / min.

KOH concentration used and reach a maximum value of 9.83%, 6.11%, 18.54% and 23.9% for the concentrations of K^+ 0.5 , 1 , 1.5 and 2 M successively, and then it is stabilized at these values.

The released amount of Cr(VI) adsorbed on CAB increases as the K^+ concentration increases [7]. The maximum amount released is recorded (Figure **2b**) for a concentration of K^+ 2 M, in which the percentage of releasing is the highest 24%, this value is reached after 2 h 30 min of stirring.

For the rest of this work and in the same experimental conditions, we will set the K^+ concentration used to 2 M.

3.2. Recycling of Activated Carbon Loaded with Cr(VI)

3.2.1. Successive Adsorption-Regeneration Cycles with Drying

The results of the releasing tests reported above have shown that it is possible to recover metals fixed on the activated carbon. It is therefore interesting to examine possible reuse of the latter and to study the variation of the retention capacity during several successive cycles.

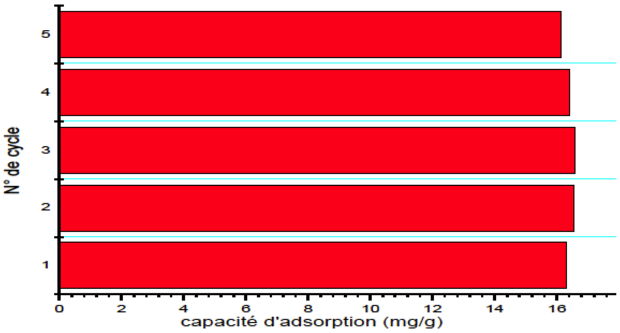

Figure 3: Evolution of the retention capacity of Cr(VI) by activated carbon as a function of number of reuse cycles m_{ads} = 0.3 g, t = 2 h, V = 50 mL, $[K^+]$ = 2 M and v = 150 Tr/min.

Figure **3** shows the evolution of the retention capacity of Cr(VI) by activated carbon CABRS, regenerated with drying during recycling, depending on number of reuse cycles. We find that the retention capacity increases slightly after the first cycle and decreases after the third cycle. It passes from 16.6 mg/L of Cr(VI) in the fourth cycle to 16.1 mg/g of Cr(VI) in the fifth cycle. This represents a loss of about 2.89% of the effectiveness of activated carbon between the third and the fifth cycle. Similar results were found by Shubo Deng who studied the retention of Cr(VI) by amino polyacrylonitrile fibers [7]. This may be attributed to the leaching of a portion of organic matter and micro-organism by the base used in the regeneration. This can cause a decrease in the number of ion binding sites of heavy metals and therefore their retention capacity.

3.2.2. Successive Adsorption Cycles without Regeneration and with Drying during Each Cycle

Figure **4** shows the evolution of the retention capacity of Cr(VI) adsorbed to the activated carbon CABNRS (unregenerate with drying after each adsorption cycle).

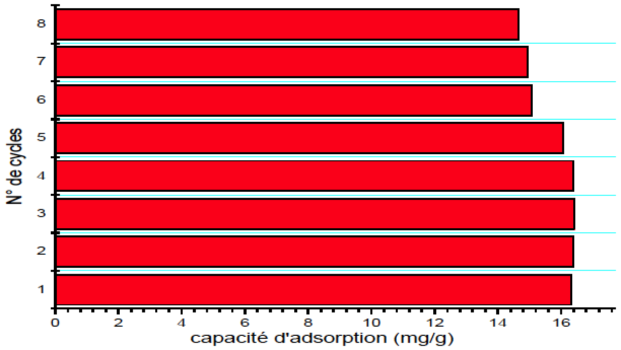

Figure 4: Evolution of the retention capacity of Cr(VI) by activated carbon as a function of number of reuse cycles m_{ads} = 0.3 g, t = 2 h, V = 50 mL, $[K^+]$ = 2 M and v = 150 Tr/min.

The application of this method requires no energy. So, ecologically, it's the most suitable for recycling activated carbon.

3.2.3. Successive Desorption Cycles

The experimental results related to the evolution of the capacity of the release of Cr(VI) ions by activated carbon depending on the number of cycles (Figure **5**) show a clear decrease of the release capacity which could reach near zero values if we went beyond 6th cycle.

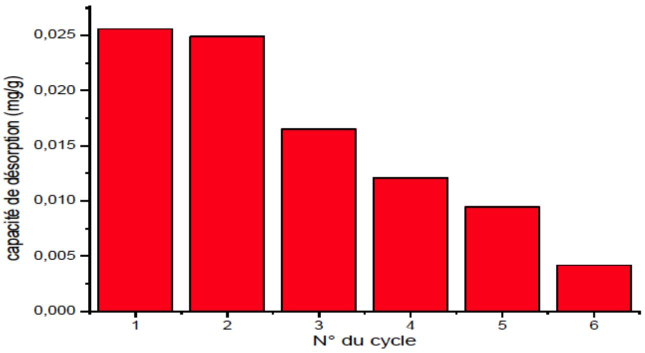

Figure 5: Evolution of the release capacity of Cr (VI) by the activated carbon as a function of number of wash cycles m_{ads} = 0.3 g, t = 2 h, V= 50 mL, $[K^+]$ = 2 M and v = 150 Tr/min.

3.3. Comparison of Results

Comparing the above results, we can observe that the adsorption capacity of Cr(VI) on activated carbon is nearly constant at 16.4 mg/g for CABNR, 16.6 mg/g for CABNRS and 16.5 mg/g for CABRS) in the first five cycles.

From ecological point of view, recycling of activated carbon CABNRS, unregenerate and drying is the most effective. In order not to cause another pollution problem, it will be treated with more chromium hexavalent desorption cycles before storage. However, the regeneration of activated carbon is a hindered process that requires the addition of reagents (base or acid) [6]. In addition, regeneration changes the structure of materials. But despite this, it remains the best solution in the case of mineral effluents heavily loaded with heavy metals and the composition is simple.

4. CONCLUSION

This study evaluates qualitatively and quantitatively activated carbon. Treatment of activated carbon saturated with hexavalent chromium helps the mitigation of adverse effects of this material to the environment and the reuse of it as adsorbent, besides its possible recycling of metal compounds. The three recycling methods used in this work are: successive adsorption-desorption cycles, successive adsorption cycles with drying of the activated carbon and successive adsorption cycles without drying of the activated carbon.

The use of a base (KOH) has recovered an amount of hexavalent chromium retained by the activated carbon CAB. This CAB regenerated was again used to set the hexavalent chromium ions during several cycles. Regeneration test results showed that the effectiveness of the CAB remains almost constant during the first four cycles and then decreases from the fifth cycle.

On the other hand, it appears that the effectiveness of the activated carbon does not change during their reuse for the removal of metal ions in solution. Activated carbon may eventually replace ion exchange resins in the processing units of industrial effluents containing heavy metals.

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