VOC adsorption-desorption cycle with activated carbon cloth : regeneration by Joule effect

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Introduction

Activated carbon cloths reveal very interesting properties for environmental applications and especially for air treatment applications [1]. Adsorption capacities and gas-solid transfer velocities are very high [2]. The electric behaviour of this material is similar to a classical ohmic conductor. Thus, the regeneration using Joule effect heating is possible [3].
This paper present adsorption-desorption cycle developed for the treatment of ethanol vapors in air. The desorption step is performed by Joule effect. The most important desorption parameters are temperature and flow velocity of the nitrogen gas used to carry out the desorbed molecules. An experimental design methodology is used to assess the impact of these two operating conditions on the desorbat concentration. The objective of this adsorption-desorption process is to concentrate the polluted effluent in sight to recover the organic compound with for example a cryogenic condensation process.

Experimental

A laboratory pilot plant (Figure 1) is used to perform adsorption stages and thermal regenerations with Joule effect, with a commercial activated carbon cloth (ACTITEX CS-1501). Altogether, there are 15 activated carbon layers arranging in this plant, which represent 25 grams of adsorbant.
Adsorption stages : the inlet concentration (C_0) is 3 g.m^{-3} of ethanol vapor and the flow rate is 5 m.h^{-1}. The outlet concentration (C_s) is measured as a function of time with a Flame Ionisation Detector. Adsorption capacities are deduced of these curves.
Desorption stages : the temperature desorption is controlled with thermocouples placed at the surface of the cloth. This temperature control the electrical generator linked to a PID regulator. Thus, The activated carbon cloth reaches the desorption temperature in a few seconds. The two desorption temperatures of the experimental design are 100 and 150 °C, and the nitrogen desorption flow velocities are 24 and 48 m.s^{-1}. The evolution of the desorbat concentration is also measured with the Flame Ionisation Detector. The relevant characteristics of the desorbat used in this study are the maximum value of the desorbat concentration and the desorption rate.

Results and Discussion

Adsorption stages
Typical breakthrough curves are obtained (see the example on Figure 2). Adsorption capacities at the breakthrough point (respectively the breakthrough time) are around 250 mg.g^{-1} (respectively 25 minutes).
Desoprtion stages
The results of the experimental design allow to assess effects of the 2 desorption parameters on the quality of the regeneration.
Effect of the desorption flow (Figure 3) :
The desorption flow essentially influences the desorbat concentration. The increasing of the flow rate causes the dilution of the outlet flow. On the other hand, the total quantity desorbed is not affected by the flow desorption.
Effect of the desorption temperature (Figure 4) :
The increasing of the desorption temperature enhances the maximum concentration and the amount of desorbed compound.

Conclusion

Activated carbon cloth allows good adsorption capacities and good regeneration using Joule effect. During the desorption phase, outlet concentration is a function of the temperature and flow rate desorption.

References

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[3] Baudu M., Le Cloirec P. and Matin G. "Thermal regeneration by Joule effect of activated carbon used for air treatment", Env. Tech., 1992, 13 (5), 423.

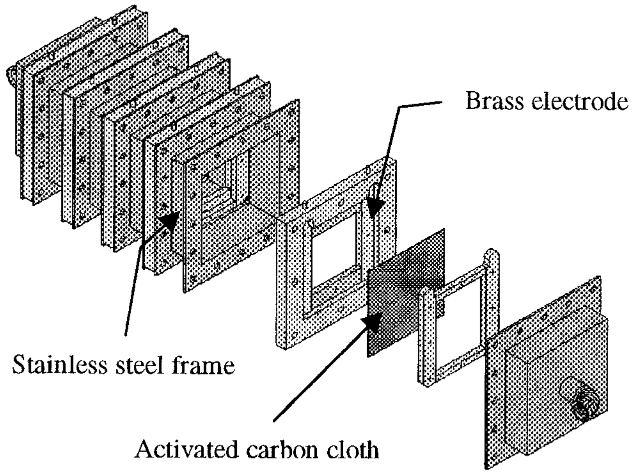

Figure 1 : Experimental setup

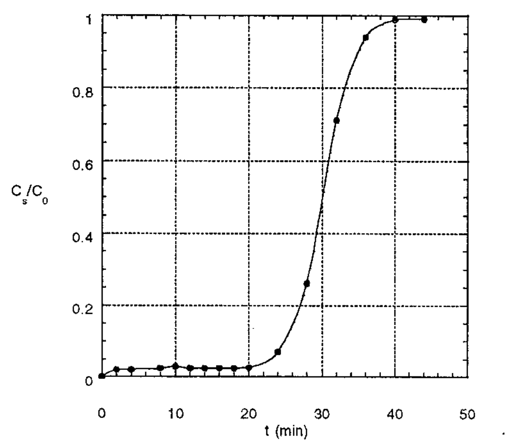

Figure 2 : Example of breakthrough curve with ethanol

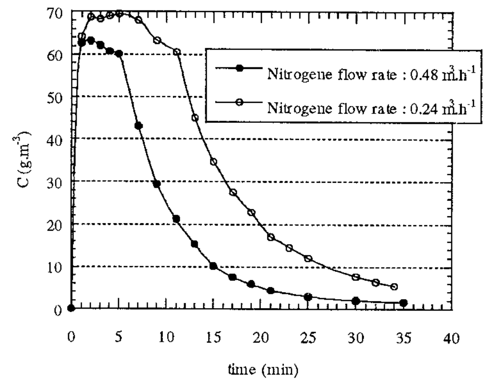

Figure 3 : Effect of the desorption flow (desorption temperature equal to 100°C)

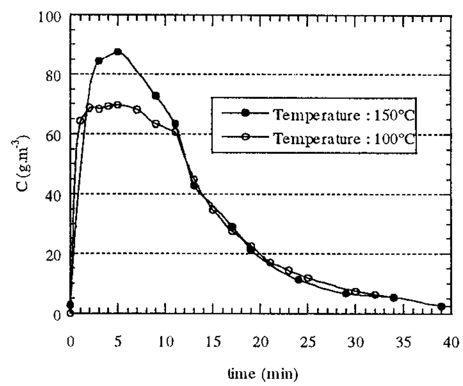

Figure 4 : Effect of desorption temperature (Flow rate equal to 24 m.s^{-1})