Prosimy cytować jako: Inż. Ap. Chem. 2009, 48, 5, 15-16

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Desorption of volatile organic compounds from activated carbon with microwave heating

Introduction

Adsorption process of volatile organic compounds from the waste gases is strictly connected with immobilization of these compounds on the activated carbon bed. That process was examined by *Nastaj et al.* [1]. Unfortunately, there is a problem with reuse of adsorbate bed in waste gases management process due to the high risk of the release into the atmosphere the compounds that had been previously trapped in the activated carbon bed. That is especially true for traditional methods of activated carbon desorption with hot steam. In order to introduce safely the organic compounds into the microbiological reactor for the utilization, there is a need for designing a different method of transferring volatile organic compounds from activated carbon pellets directly into water. The idea of using microwaves to enhance desorption process was widely analyzed by *Cherbanski et al.* [2]. Microwave applications in environmental engineering were described by *Jones et al.* [3]. A very popular application is related to use of microwaves as a mean of decomposition an organic compound closed in activated carbon bed [4]. Adsorbed compounds are strongly bound to absorbent; their transfer to the liquid phase requires supplying an adequate amount of energy. Use of electromagnetic energy from microwaves can be a good solution for that objective. The specific features of microwaves are huge advantage in desorption process due to the carbon susceptibility on the electromagnetic energy. The heat generation caused by microwave irradiation appears directly in the carbon pellets, where process desorption takes place. Additional tests (including IR photometry) proved that carbon pellets temperature was higher than water temperature. That phenomenon allows to conduct the desorption in lower temperature, than process conducted traditionally with steam. Benzene was chosen deliberately. Firstly, it is non polar compound so, it will not interact with microwaves and all thermal effects can be limited to both activated carbon and water interaction with electromagnetic energy. Secondly, benzene has a very limited solubility in water, therefore its transfer to the water will be significantly harder and the use of microwave seems to be a good solution. The main aim of this work was conducting the preliminary desorption tests in a laboratory scale in a continuous experimental setup.

Experimental setup

The experiments were conducted in laboratory scale in the experimental setup shown in the Figure 1. Small amount of activated carbon (10 g) with previously adsorbed benzene was placed in tank (E-1) inside microwave chamber.

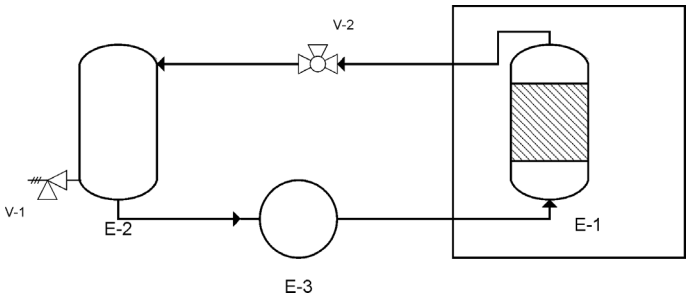

Fig. 1. Experimental setup with two pressure vesels. E-1 – tank with activated carbon bed placed in the microwave chamber, E-2 – tank outside the microwave chamber, valve V-2 for sample drawing, E-3 – pump, V-1 – pressure safety valve

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Water (total 5 liters) was circulating between two tanks (E-1, E-2); the flow was slightly forced with pump (E-3). The samples of water for measurement of benzene concentration were drawn from valve (V-2) in the determined time intervals. The water samples were analyzed with spectrophotometer. The desorption tests were conducted with 100 and 400 W of nominal microwave power. During the whole experiment temperature of water both at the inlet and outlet microwave chamber was measured with thermocouples inserted into the pipes.

Experimental results

In order to properly compare the results the parameter of desorption efficiency η was introduced according to the equation:

$$\eta = \frac{X_0 - X}{X_0} \cdot 100\% \qquad (1)$$

X_0 means the initial concentration of benzene in activated carbon bed, X – concentration of benzene in activated carbon bed during the experiment. The comparison of η for two power levels is shown in Fig. 2.

The desorption efficiency depends on the used microwave power level. Process conducted with 400 W of nominal microwave power level took less time (150 seconds at 400 W versus 3000 s at 100 W). Use of higher microwave levels has strong effect on the process course and rate. Figure 3 presents the changes in temperature of water that flew out the tank in the microwave chamber. Process conducted with 400 W microwaves leads to almost 75°C water temperature. Use of 100 W rises water temperature to the level of 63 °C. The temperature differences in both cases are not proportional to the microwave power levels differences. However, the patterns of temperature rise are similar in both cases. In the beginning of the process temperature increase is small, however, after a specific time, the temperature of water rises to the maximum level, which corresponds to the increasing the rate of desorption (Figure 2).

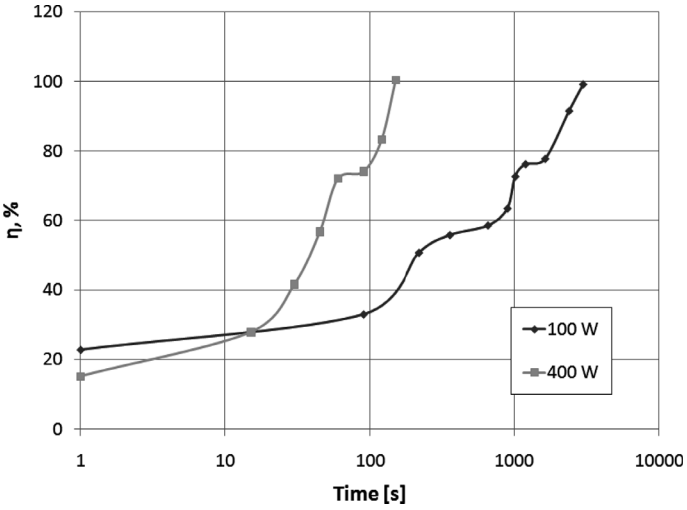

Fig. 2. Comparison of benzene desorption efficiency in process conducted with microwaves with different power levels

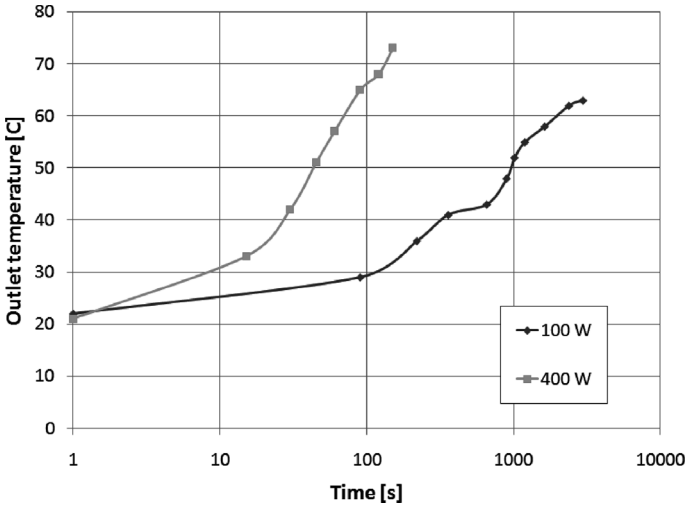

Fig. 3. Temperature rise in outlet water from the microwave chamber

Conclusions

There is a possibility of using the microwave energy to conduct the process of desorption of volatile organic compounds. The transfer of benzene to the aqueous phase was conducted without steam, with the microwave energy as the only energy source. Due to the specific microwave and carbon features, microwave energy interacts mainly with carbon pellets. The role of water was reduced to the cooling medium and the transporter of desorbed organic compound out of the carbon bed. The whole process was conducted with relatively low temperatures, which increases the chances of successful reuse of carbon in adsorption process. As the result, the benzene was moved from the carbon pellets into water solution, despite the non-polar benzene character and its weak solubility in water. The next step of the experiments will be focused on the comparison of traditional steam desorption with the microwave one.

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