Topic number: 1

Application of a multi stage packed-bed reactor for destruction of volatile organic compounds under atmospheric conditions

Marko Hübner(1,*), Olivier Guaitella(2), Antoine Rousseau(2) and Jürgen Röpcke(1)

(1) INP Greifswald e.V., Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany
(2) Laboratoire de Physique des Plasmas, Ecole Polytechnique, CNRS, 91128 Palaiseau, France
(*)**huebner@inp-greifswald.de**

New regulations concerning indoor air quality require the treatment of volatile organic compounds, VOC. They are used for example as solvents in paints or inks and hence they are emitted from modern furniture or indoor paintings. Some VOCs are very toxic, even at low concentrations, what causes a need for new abatement technologies. From the economical point of view decontamination at atmospheric conditions (atmospheric pressure, near room temperature) is expected to be the most valuable method.

This contribution shows a method for VOC destruction based on a new approach introduced by Whitehead and co-workers. They assembled several normal packed-bed reactors in series. Harling [1] has been reported, that such an arrangement of several stages (one packed-bed reactor) in series increases the VOC destruction rate nonlinear compared to a parallel arrangement. This synergistic effect has been investigated.

One stage is made of two stainless steel grid shaped electrodes. For simplicity, the space between them is packed with only one layer of glass beads each of them with a diameter of 6mm. The VOC contaminated gas flows perpendicular to the electrodes through the fill, figure 1.

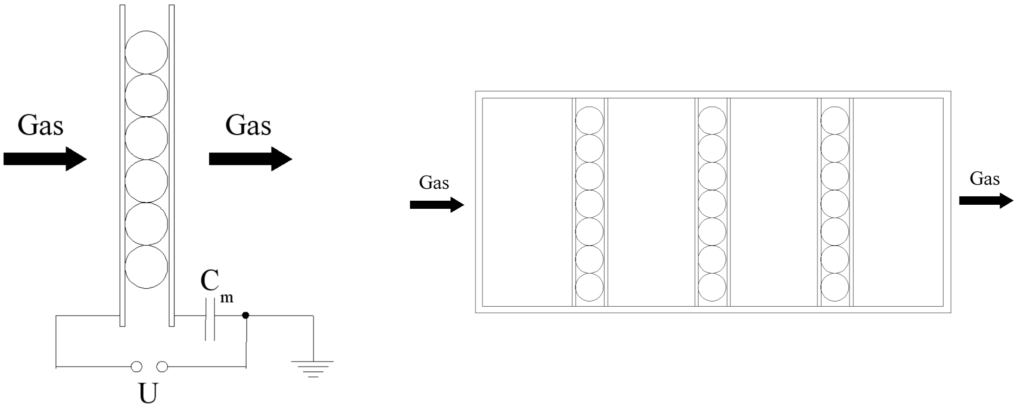

Fig. 1: Principal draw of one stage (left side) and assembled alignment of three stages in series (right side). One stage is made of two stainless steel electrodes filled with glass beads. The contaminated gas flows perpendicular to the stages. The consumed power was determined using a measurement capacity, C_m, and the Lissajous figure method [2].

For all experiments, humidified synthetic air was contaminated with the test-VOC ethylene. The number of active stages was varied from 1 to 3. The influence of the initial ethylene concentration to the VOC destruction rate has also been investigated. The dependence on the surface structure of the packed material and the resulting by-product creation rates were also studied. All gas compositions were identified and quantified using Fourier Transform Infrared (FTIR) and tunable diode laser (TDL) absorption spectroscopy.

As an example, the ethylene concentration of synthetic air was set to 1000ppm at a flow of 1 slm and then guided into the reactor which was equipped with one, two or three stages. All three stage combinations were fed with an ac sinusoidal voltage with different peak to peak values at a frequency of 1 kHz.

Figure 2 shows the concentration of the main end products after passing the stages fed with sinusoidal voltage with U_{PP} = 12kV. The amount of water corresponds to the initial water concentration. As one can see from figure 2 the ethylene concentration decreases to about 40ppm after passing all three stages.

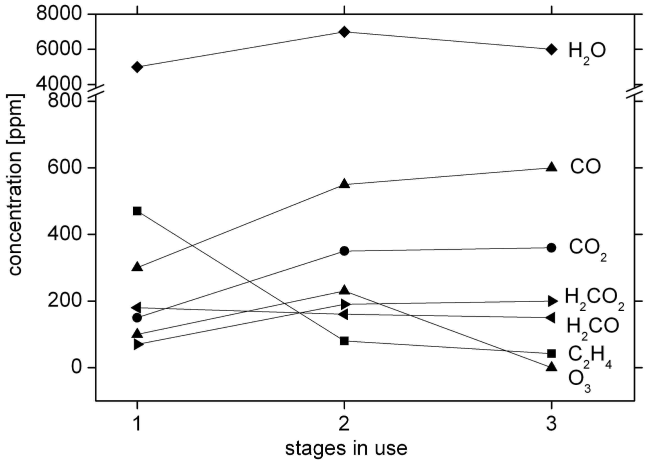

Fig. 2: Concentration of the main end products after passing the reactor equipped with 1, 2 or 3 stages. The stages were fed with sinusoidal voltage with U_{PP} = 12kV at a frequency of 1 kHz. The initial ethylene concentration was 1000ppm.

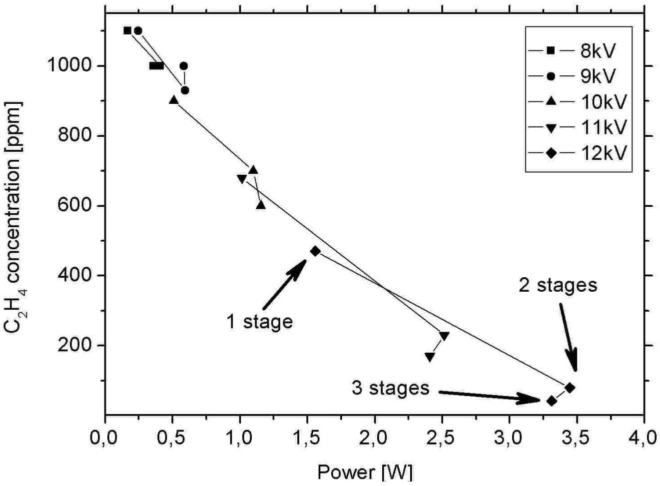

Fig. 3: Concentration of ethylene versus the consumed power for different applied voltages. For each curve: from left 1, 2, 3 stage(s) in use. The specified voltages are peak to peak values of a sinusoidal voltage at a frequency of 1 kHz.

Figure 3 shows a linear behavior of all measurements. Thus the synergistic effect mentioned above does not appear under the described circumstances. Work is on progress to measure the dependency on the flow rate of the contaminated gas as well as the dependency on the possibly pressure drop caused by each stage and the resulting change of the residence time of the gas inside one stage.

References

[1] A.M. Harling, D.J. Glover, J.C. Whitehead and K. Zhang, 2008 *Environ. Sci. Technol.* **42** 4546

[2] Z. Falkenstein and J.J. Coogan, 1997 *J. Phys. D: Appl. Phys* **30** 817