Surface & Coatings Technology 234 (2013) 126–131

Contents lists available at ScienceDirect

Surface & Coatings Technology

journal homepage: www.elsevier.com/locate/surfcoat

# Effect of atmospheric surface plasma on the adsorption of ethanol at activated carbon filter element

Ralf Basner, Altyn Akimalieva, Ronny Brandenburg *

*INP Greifswald, Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany*

ARTICLE INFO

Available online 19 November 2012

*Keywords:*
Dielectric barrier discharge
Exhaust treatment
VOC removal
Ethanol
Active carbon
Adsorption

ABSTRACT

Atmospheric non-thermal plasma has been recognized as a successful tool for the treatment of exhaust and waste air for abatement of pollutants, air cleaning, and odor removal. To improve the efficiency of plasma cleaning processes a combination of plasma with adsorption filters and or catalysts is used. The fundamental interaction mechanisms of the surface, plasma, and gas remain the subject of further investigations of the details. A quantitative FTIR-spectroscopic study of the effect of surface barrier discharge on the adsorption and desorption of ethanol at activated carbon is presented. First of all the adsorption and desorption were characterized for different input concentrations and different carrier gas flows without operating the plasma. After that the interaction of the plasma and the gas mixture was analyzed. Finally the activated carbon filter was reinstalled behind the plasma stage and the loading and unloading of the activated carbon filter element were investigated while burning the plasma. It is shown that the plasma stage initiates an additional decomposition of ethanol at the surface of the activated carbon because of the interaction of long-lived $O_3$ with physical adsorbed $C_2H_5OH$. The total amount of filtered $C_2H_5OH$ does not change but the portion of decomposed $C_2H_5OH$ that is not rinsed out increases. The plasma caused effect at the surface reaches 68% of the effect of plasma in the gas phase.

© 2012 Elsevier B.V. All rights reserved.

## 1. Introduction

The deodorization of air and the reduction of emissions from waste air and exhaust gas are becoming increasingly important issues in industrialized society. Due to its impact on air, soil and water exhaust pollutions affect the whole environment and thus human health. Therefore environmental norms and standards are constantly increased by national and international authorities. The possibility to use atmospheric non-thermal plasmas for air-pollution control is well known [1–6]. Plasmas contain active and highly reactive species, in particular electrons, ions, atoms, molecules, and radicals, which can decompose pollutant molecules and particulate matter in the gas phase (aerosols) and on surfaces. In most applications the problem is so complex that plasma technology has to be combined with classic filter methods like adsorption and scrubbing to get satisfactory results. However, the fundamental interaction mechanisms of the surface, plasma, and gas remain subject of further investigations of the details. This paper intends to contribute to clarifying aspects of the effect of non-thermal plasma on gas adsorption on surfaces. In particular a quantitative FTIR-spectroscopic study of the effect of atmospheric surface barrier discharge on ethanol in the gas phase and its adsorption and desorption at activated carbon (ac) will be presented. Since this study intends to the inaction of active carbon and plasma species a VOC was selected which is known for pure physisorption. Ethanol fulfills this requirement and is easy to handle in time consuming experiments. Furthermore, ethanol is the most abundant VOC emitted from corn silage and thus a major contributor to tropospheric ozone from agricultural sources [7]. The occupational exposure limit of ethanol in Germany is 500 ppm [8].

## 2. Experiment

Fig. 1 shows a sketch of the experimental setup including ac filter element, gas handling, power supply and measuring systems of plasma power, temperature and humidity of gas and its composition. Synthetic air ($N_2/O_2 = 80/20$) enriched with ethanol was used as carrier gas. This experiment was specifically designed to study the effect of atmospheric pressure plasma on adsorption and desorption of ethanol at activated carbon.

The setup consists of a box made of polymethyl methacrylate (PMMA) (volume: $13 \times 43 \times 13.5$ cm³ = 7.5 L) containing a plate with several holes for gas distribution, the atmospheric pressure plasma stage and behind that the activated carbon filter element (ac filter element). Atmospheric pressure plasma stage serves a surface barrier discharge consisting of four dielectric plates ($17 \times 13$ cm), each covered with a mesh electrode from both sides.

The ac filter element is a 5 cm long PMMA-tube with an inner diameter of 1.1 cm. It is filled with 1.65 g of activated carbon particles of cylindrical geometry (AFA-2-1200). The gas composition (if not

* Corresponding author. Tel.: +49 3834 5543818; fax: +49 3834 554301.
*E-mail address:* brandenburg@inp-greifswald.de (R. Brandenburg).

0257-8972/$ – see front matter © 2012 Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.surfcoat.2012.11.028

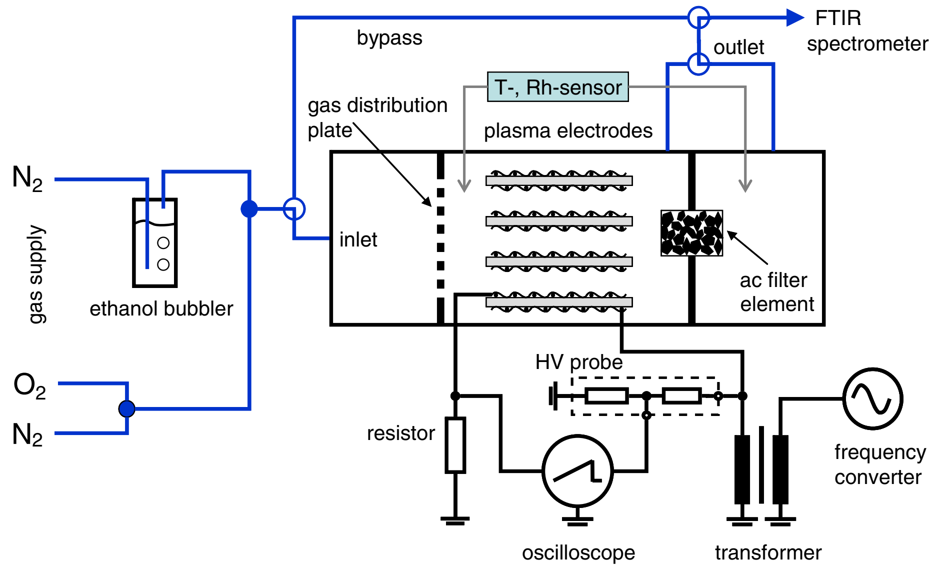


**Fig. 1.** Experimental setup.

noted otherwise) was measured with a Fourier transform infrared spectrometer (Gasmet CR-2000 FTIR, ANSYCO GmbH) with a resolution of 8 $cm^{-1}$. The temperature and the humidity of the carrier gas were measured using commercial sensors placed in front of the plasma stage and behind the ac filter element. The added bypass enables the direct measurement of the gas composition at the inlet of the filter. All experiments were performed at room temperature under normal atmospheric pressure.

Firstly the flow characteristics of the filter were determined by measuring the breakthrough curves with an empty filter element for different input concentrations of ethanol (500–2000 ppm) and different carrier gas flows (300–1000 L $h^{-1}$) without operating the plasma. These experiments give the standards for the total amount of $C_2H_5OH$ that passed through the system to enable comparison with the subsequent measurements. Fig. 2a shows the typical behavior for the empty filter element without plasma. The integral over time represents the total amount of $C_2H_5OH$ that flowed through the system.

Then the ac filter element was then filled with activated carbon to study adsorption and desorption of ethanol without operating plasma for the same concentrations and flows (Fig. 2b). The integral over

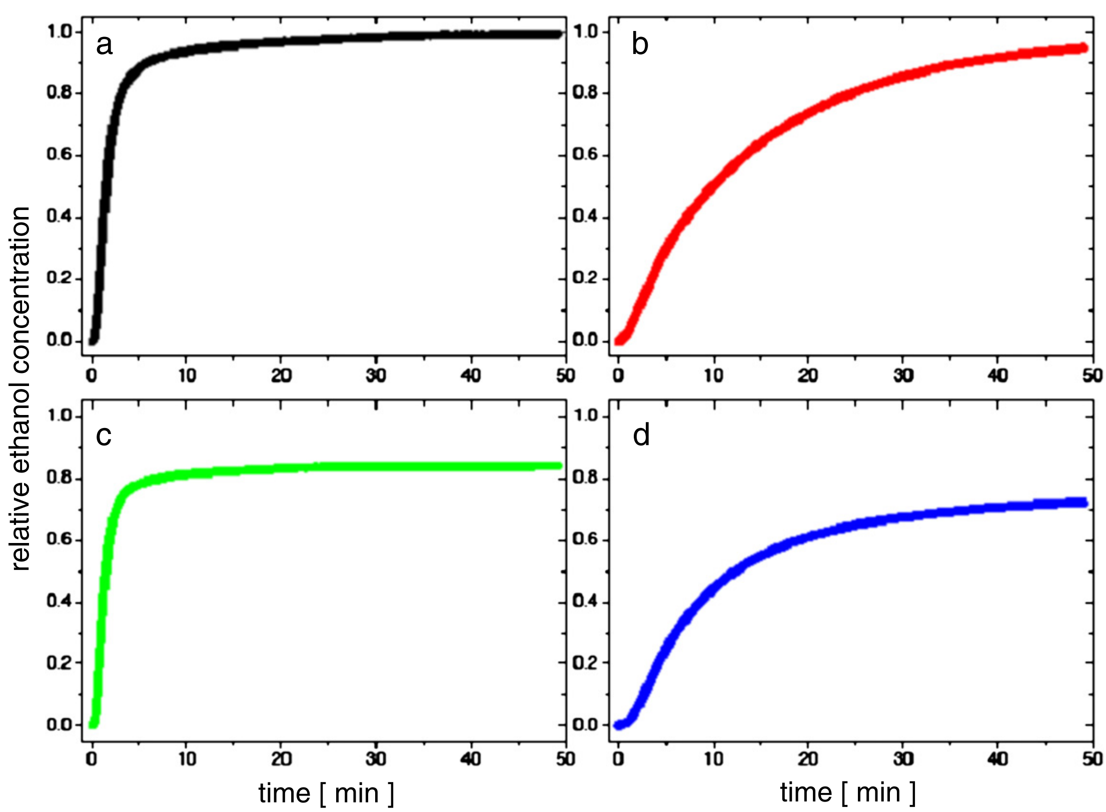


**Fig. 2.** Relative breakthrough curves ($c(t)/c_{bypass}(t)$) for an input of ethanol concentration of 1000 ppm, a volume flow of 300 L $h^{-1}$, and a specific energy density of 46 J $L^{-1}$ a) without activated carbon/without plasma, b) with activated carbon/without plasma, c) without activated carbon/with plasma, and d) with activated carbon/with plasma.

Download English Version:

https://daneshyari.com/en/article/8029408

Download Persian Version:

https://daneshyari.com/article/8029408

Daneshyari.com