PlasTEP

plasma for environment protection

Field test at Gehrkescher Hof in Wilmshagen/Germany

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Executive Summary

A field test was performed in order to investigate the feasibility of the treatment of agricultural exhaust air by means of plasma technology. The plasma source, the power supply and the sensitive analytical devices were successful applied and operated but the concentrations of the impurities were too small to get reliable statements about the conversion of pollutants

Introduction

The agricultural holding „Gehrkescher Hof“ locates between Stralsund and Greifswald in the North-Eastern part of Germany and runs, besides others, pig breeding. This is connected to the production of exhaust air contaminated with bad smelling compounds. Important components of the exhaust air of pig breeding sites air smells and ammonia[1]. The removal of these components by means of plasma-based technology was the aim of the herewith reported field test.

Experimental procedure

In Figure 1 the exhaust duct of the ventilation system is shown together with the flexible tube leading the sample gas to the experimental setup. The experimental setup used is schematically depicted in Figure 2. The exhaust air was sucked from the ventilation system of the hog house through the plasma source by means of a ventilator. Sample probes were extracted from the exhaust air stream and directed to an FTIR-spectrometer (**F**ourier-**T**ransform **I**nfra-**R**ed-spectrometer) as well as an FID (**F**lame-**I**onization-**D**etector). To protect the sensitive diagnostic equipment from damage appropriate filters were installed. The data of the gas analysis were stored on a computer in real-time. The plasma source was operated with a programmable **h**igh-**v**oltage (HV) power source. The electrical operation parameters were investigated by a digital oscilloscope and voltage and current probes.

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Figure 1: Exhaust duct of the ventilation with flexible tube for sample gas

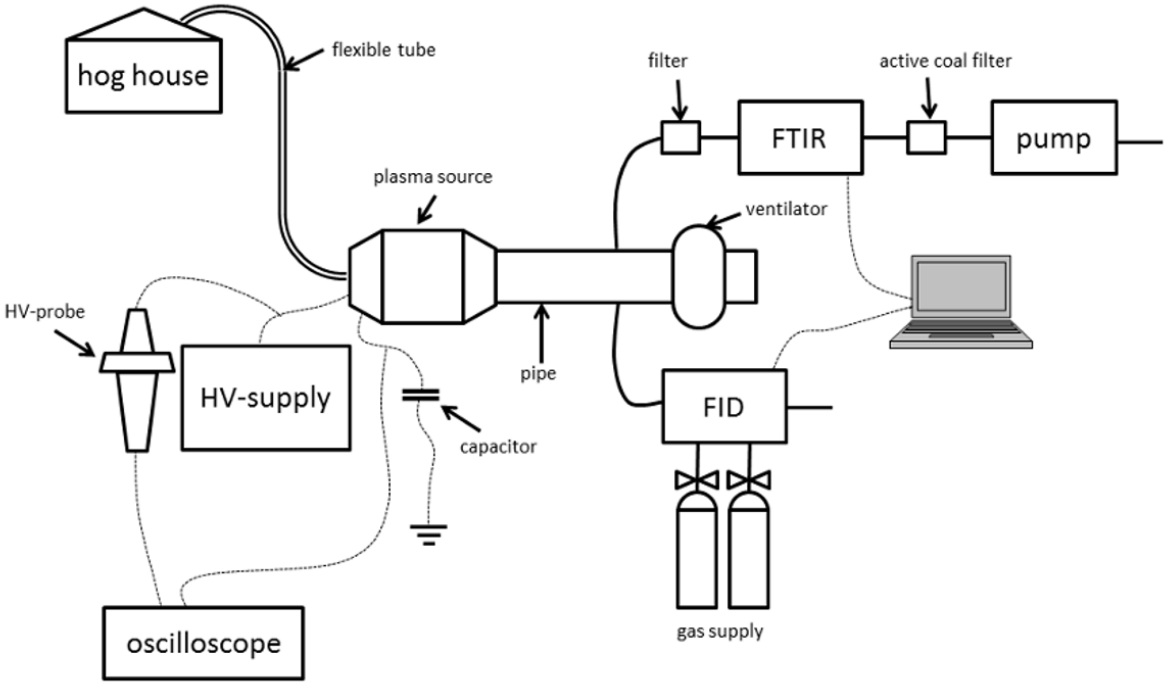

Figure 2: Scheme of the experimental setup

Results

Unspecific bad smells are often recognized due to the presence of **v**olatile **o**rganic **c**ompounds (VOC`s). In this field test an FID was used to analyze the concentrations of the VOC´s. The results of these measurements are shown in Figure 3. The black curve displays the value of the hydrocarbon-bonded carbon atoms in ppm (**p**arts **p**er **m**illion) measured with the FID. The red curve correlates with the **s**pecific **e**nergy **d**ensity (SED), which is calculated by the division of the power dissipated into the plasma and the according gas flow.

The values displayed fluctuate around a value of about 12 ppm. A reliable correlation with the applied energy density cannot be drawn. Only a clue for the VOC-removal by plasma can be found in the area light gray marked. Here, a significant decrease of the VOC-concentration is to be found shortly after the application of the highest energy density. However, reliable, qualified statement about the feasibility of plasma-based technology for VOC-removal in agricultural exhaust air cannot be concluded from this results.

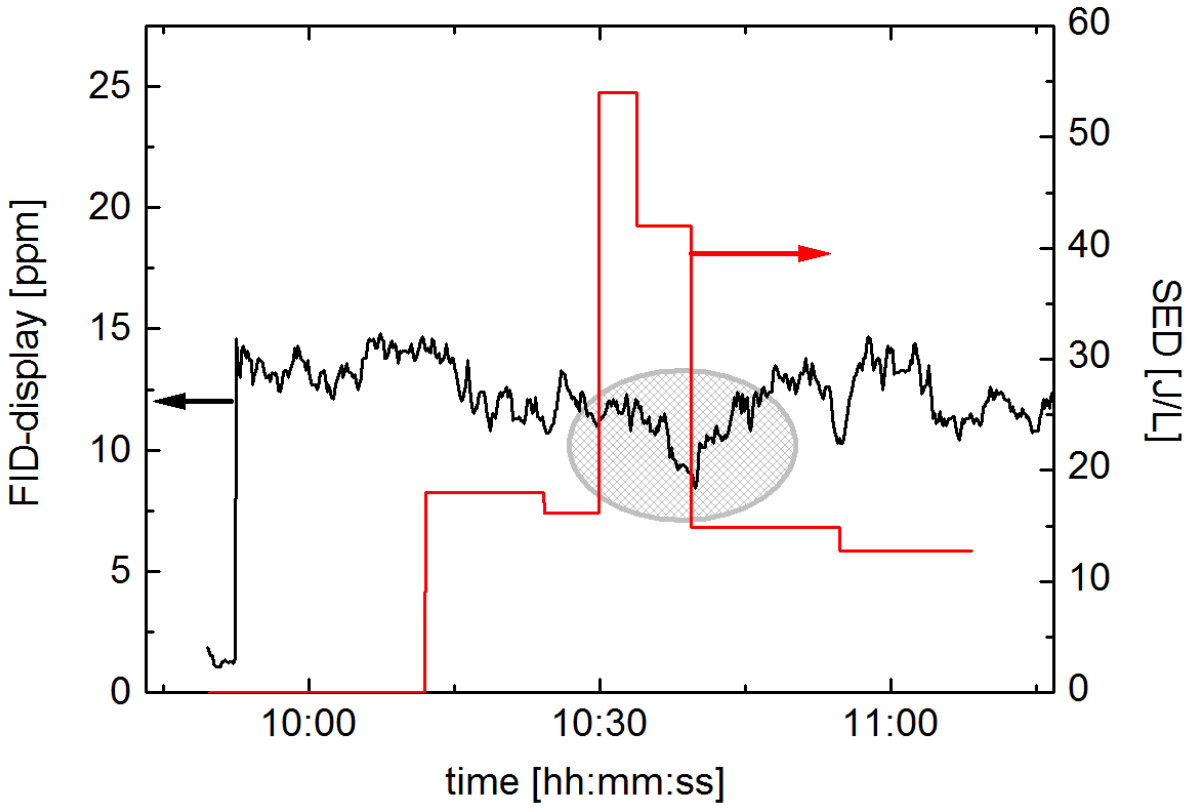

Figure 3: FID-display (black curve) and correlating specific energy density (SED, red curve)

Since the contamination of the exhaust air from pig breeding with bad smelling compounds besides VOC´s also is due to the presence of ammonia, the analysis of the recorded infrared spectra was focused on this compound.

A representative example is given in Figure 4. The black curve corresponds with the absorption of the components present in the investigated gas mixture. The red curve correlates with the absorption of the ammonia reference. Obviously, in the spectral region related to ammonia absorption there are no absorption bands detectable in the spectrum of the exhaust air, although the smell of ammonia was recognized by all participants of the experiments. The lack of these absorption bands is thought to be due to the small threshold for odour recognition of ammonia, which is given by Smeets et.al. with 2.6 ppm[2]. The infrared absorption of a component with this concentration is so small that it is not detectable in an infrared spectrum.

In the spectrum of the analyzed gas mixture significant absorption bands are detectable in the spectral range between 1000 and 1075 cm^{-1}. These absorption show the presence of ozone. Ozone is the main stable component produced by a plasma operated in air. The presence of ozone shows clearly that the plasma source operates as expected.

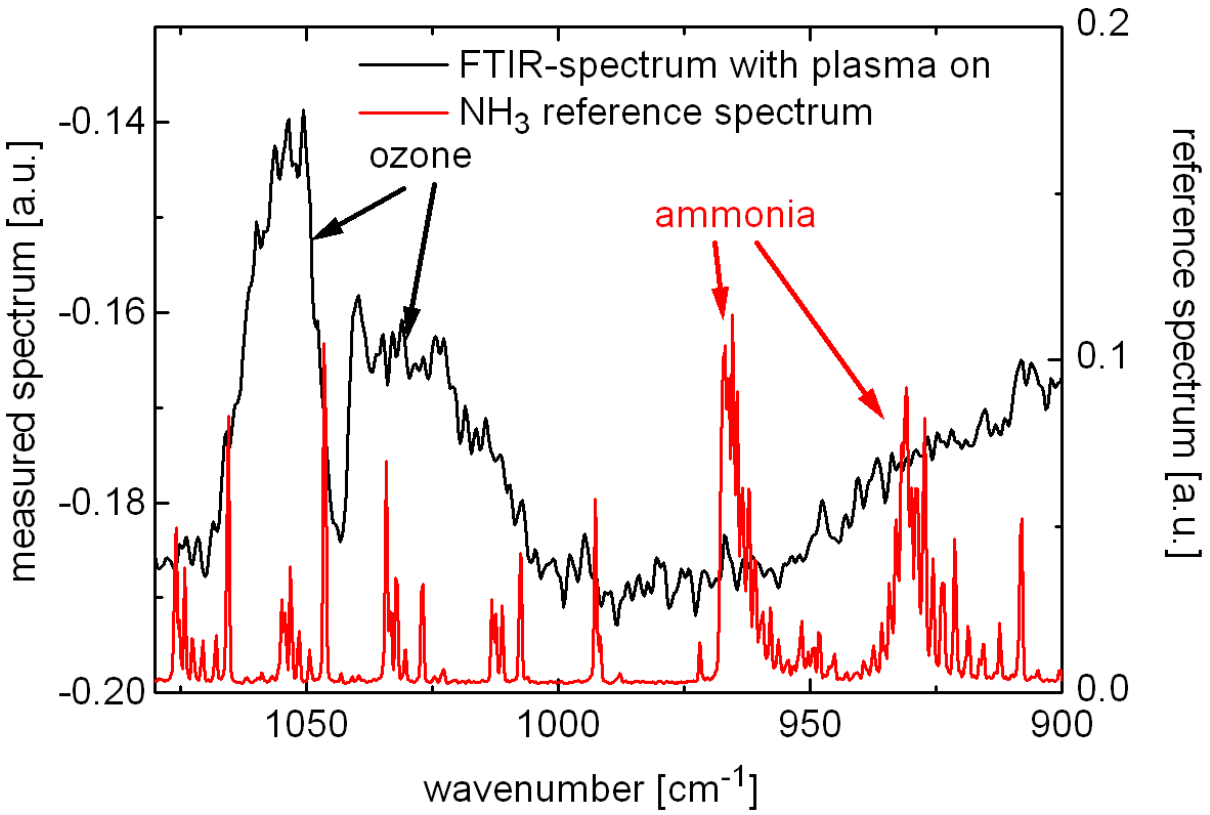

Figure 4: Sample of the infrared spectrum of the analysed exhaust air (black) and reference spectrum of ammonia (red)

According to the owner of the pig breeding site also hydrogen sulfide emissions contribute significantly to the smell nuisance. Therefore, the recorded infrared spectra were investigated for absorption bands of hydrogen sulfide. In the relevant spectral ranges no absorption bands could be detected. This also is thought to be due to the small threshold for the odour recognition of hydrogen sulfide, which is with values below 1 ppm and thus even smaller than that of ammonia[3].

Summary

During the performed field test the mobile plasma system and the diagnostic equipment were installed and operated successfully. Since the threshold values for the recognition of the bad smelling compounds are quite small, these components could be smelled by participants of the experiments but neither detected with the FTIR-spectrometer nor with the FID.

Therefore, for the diagnostic of agricultural exhaust air the diagnostical apparatus used is not applicable. For the detection of trace gases in the sub-ppm-range the application of laser-based infrared spectroscopy (e.g. Q-MACS trace) or mass spectrometry based gas chromatography (GC-MS) should be taken into account.

Because of the high amount of exhaust air to be treated a cyclic process should be taken into account to ensure the economic efficiency of the exhaust air treatment system. In this process the impurities are collected in an adsorber, which is cyclical regenerated by a plasma application. The regeneration of loaded adsorbing material should be tested in additional experiments.

References

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[3] H_2S Safety Factsheet, online verfügbar unter: http://www.safetydirectory.com/hazardous_substances/hydrogen_sulfide/fact_sheet.htm