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Removal of irritant gas emissions via a dielectric barrier discharcharge

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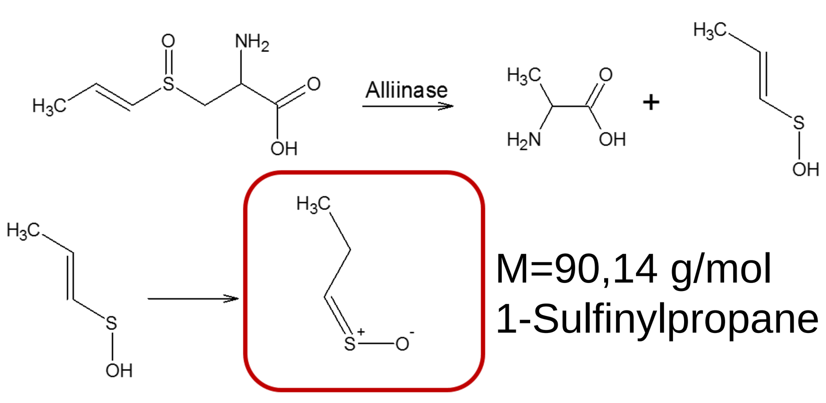
Introduction

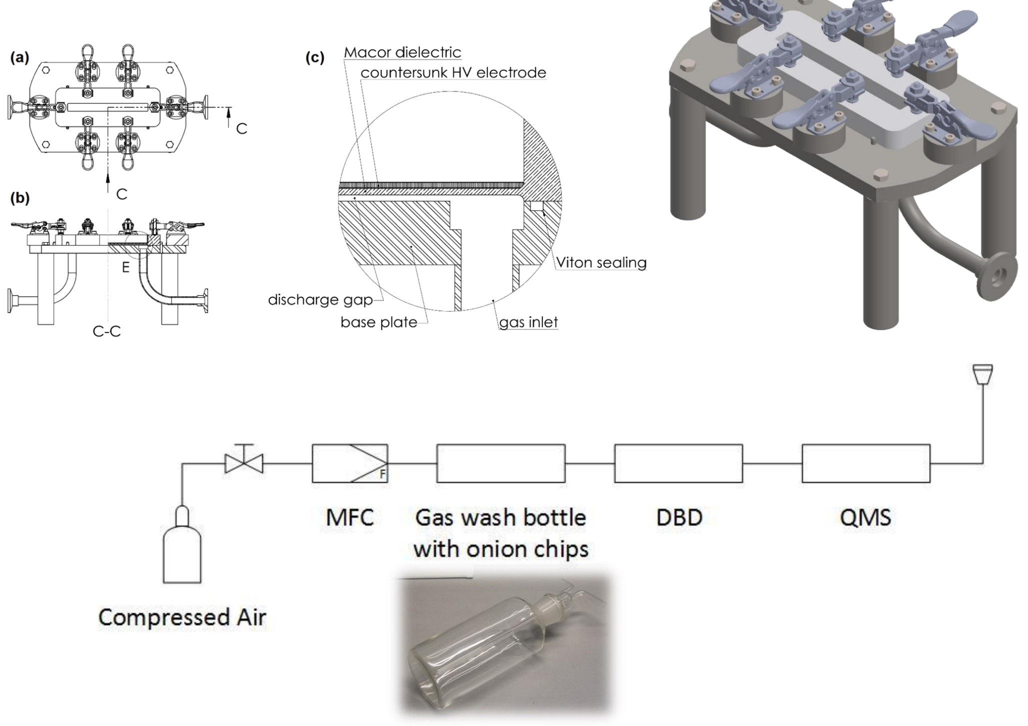
Irritant gases are released in different industrial processes, e.g. from onions and allium during grocery production. In this example, the irritant gas compound 1-Sulfinylpropane is generated in direct contact with air via the conversion of isoalliin by the enzyme alliinase. In many cases, ventilation cannot be employed, e.g. if refridgeration below room temperature needs to be ensured, whereas no effective filters are available at reasonable costs.
In this study, we used a dielectric barrier discharge (DBD) for the decomposition of the irritant gas in atmospheric air. To understand this process, the underlying reactions and mechanisms are investigated. For this particular example, the experimental realization is rather complicated, since no synthesis route exists and the gaseous compound has not been isolated, so far. Therefore, biological resources have to be employed. These natural resources complicate the analysis and interpretation of the experimental results due to the presence of many different organic compounds in the gas mixture and their natural variations in composition. In a preliminary study, we tried to demonstrate the decomposition process using an existing setup, and discuss the reaction products and their implications. The subsequent experiments, we try to identify reaction paths, the reactive species involved, and the mechanisms behind this process.



Preliminary study

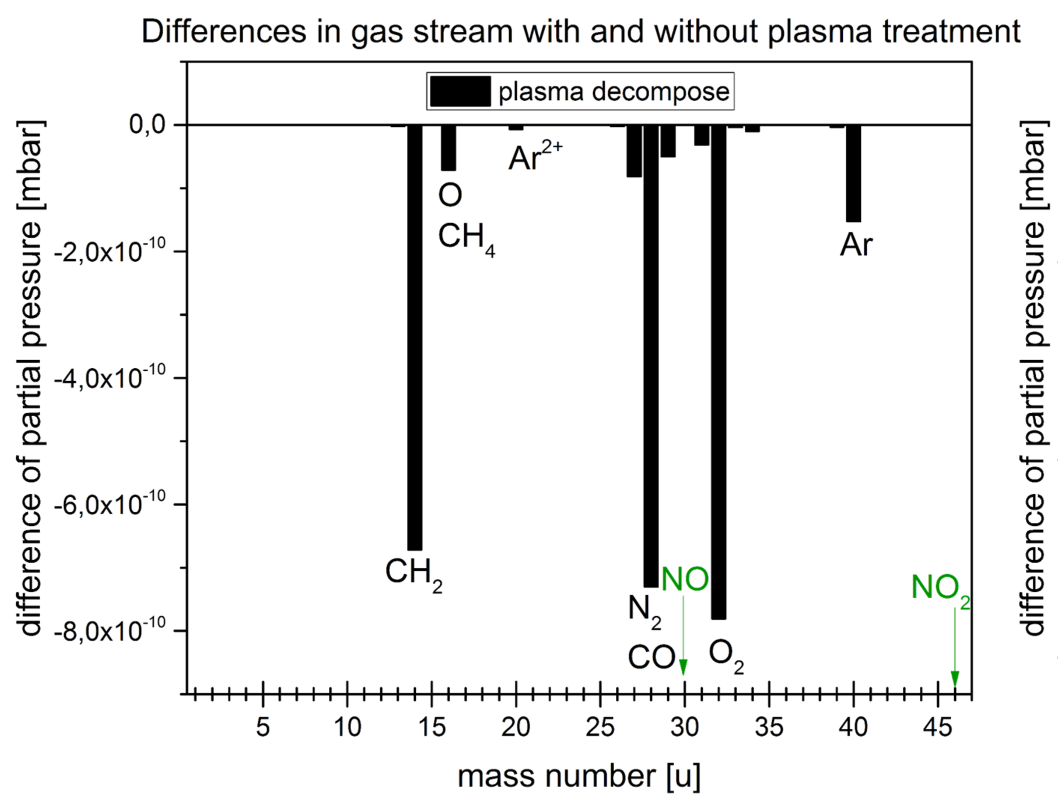
Experimental setup

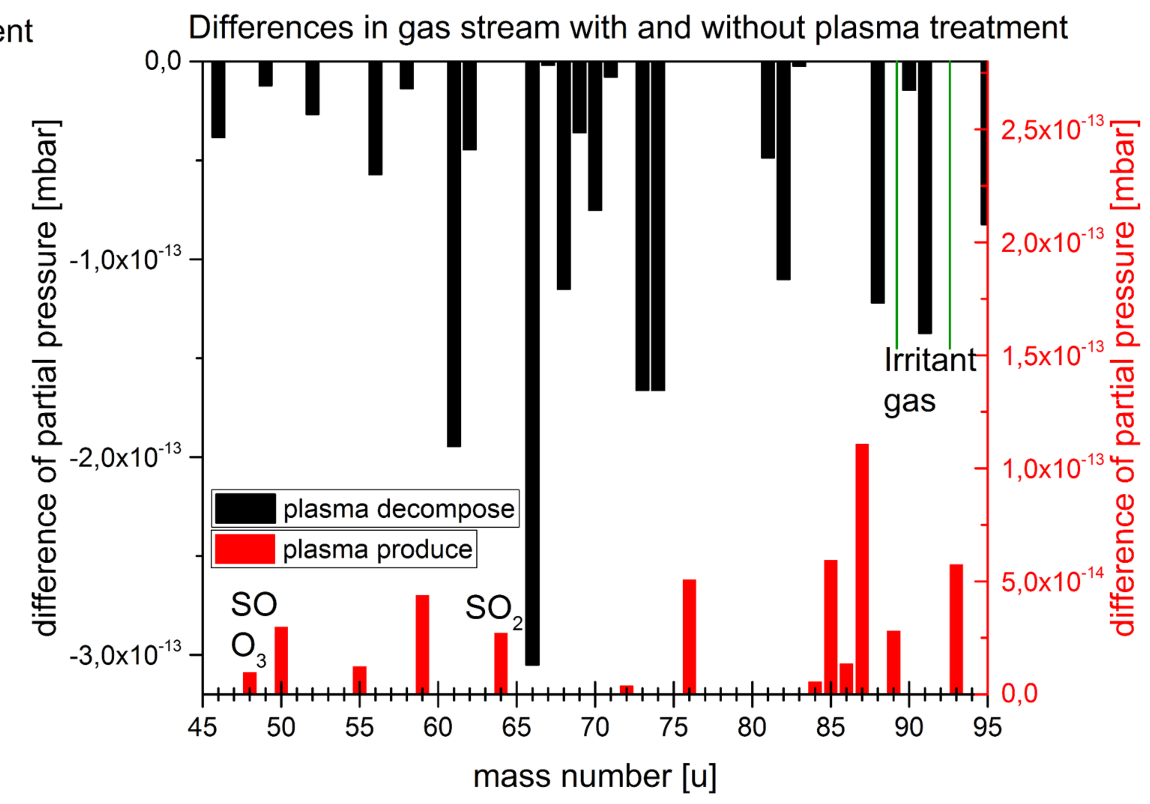
As experimental setup a DBD reactor with a gas treatment area of 100 x 10 mm^2 and a discharge gap of 1 mm from an earlier study on gas purification [4] was used.



The irritant gas stream was produced via streaming of compressed air through crushed onions in a gas wash bottle. Commercial gas flow controllers (red-y smart GSC-C, Vögtlin Instruments AG) ensured a constant CA flow rate of 3,13 SLM. The DBD reactor was operated with HV short pulses (0.6s, 11.33kV, 10kHz) from a commercial generator (Ingenieurbüro Dr. Jürgen Klein, S/N 040-3). The gas stream was analyzed with and without plasma treatment using a commercial system based on a quadrupole mass spectrometer (Multigas Analyzer, MFM analytical systems).

Results



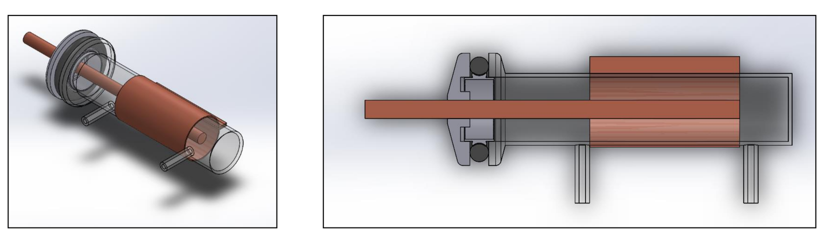


- 1-Sulfinylpropane reduction below the detection limit
- SO_x generation: below 1 ppm ➔ uncritical concentration
- No production of other harmful gas components:
  - No NO_x detected
  - No CO detected
  - Ozone detected

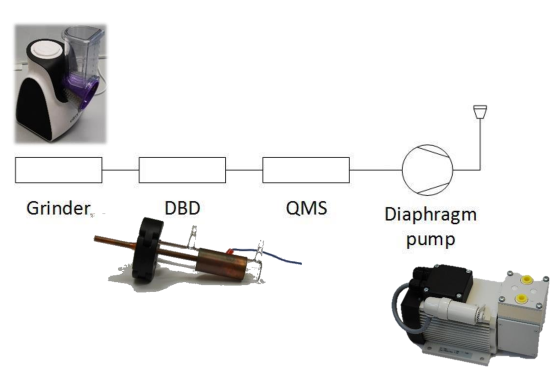
- Same batch of raw product yielded well reproduced results, but
- Irritant concentration only temporarily stable, thus
- Setup suited for single measurements, not for continuous operation.

Further experiments

The main problem is to yield a continuous gas stream with stable gas concentrations of the irritant gas component. To overcome this, a commercial grinder (Ellrona Multireibe, Braukmann) is equipped with an extension for gas extraction and attached to a gas line. During the continous grinding process, the irritnat gas is produced in a stable condentration except for natural variations. The irritant-loaded gas is extracted from the grinding system using a commercial diaphragm pump (MP30, M&C TechGroup Germany), passing a DBD reactor and commercial mass spectrometer (Multigas analyzer, MFM analytical systems).
The DBD reactor (see sketches below) has been built from a Quartz glass tube with an inner diameter of 20 mm, a length of 100 mm and a KF16 flange on top. The tube has been fitted with inlet and outlet short feed pipes with inner diameters of 2 mm. An internal HV electrode with a diameter of 4 mm and a length of 95 mm is mounted at the KF flange. An external grounded electrode is wrapped around the Quartz tube over a length of 45 mm.



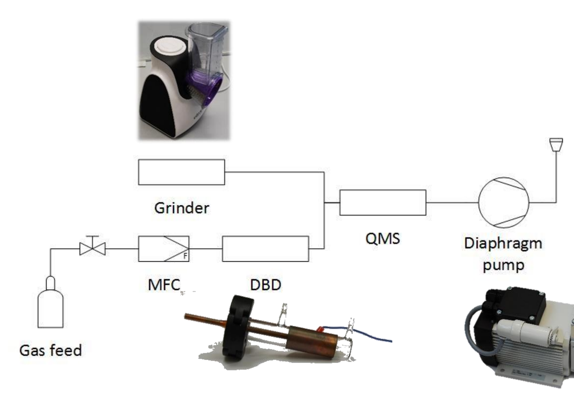
(a) Direct DBD treatment



- Stable gas flow
- Reproducible irritant gas concentration

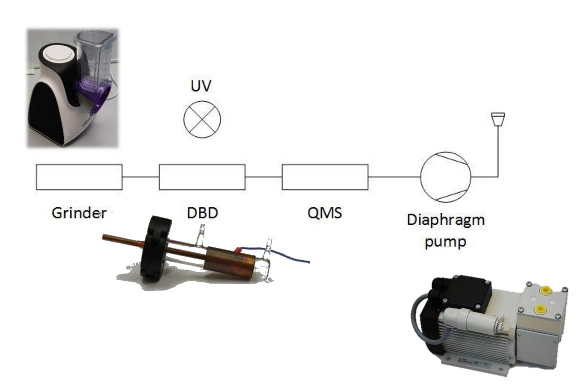
- DBD parameter study, i.e. variation of voltage, frequency, flow rate

(b) DBD afterglow treatment



- Intermixing of irritant-containing air stream with DBD afterglow in
  - Air
  - Nitrogen

(C) UV treatment



- Influence of UV radiation only via commercial lamp (LAX 1450, Müller)

- Comparing results from the different experimental setups (see above) gives way to identify the possible plasma species responsible for the reaction, i.e. short-lived species (like electrons or radicals), long-lived species (like metastables or ozone), or UV photons.

- Comparing results for different carrier gases (air, nitrogen) and gas compositions renders possible further deductions on the mechanisms and reaction paths.

Literature

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Support

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Plasma-
Enhanced
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