P 18: Atmospheric Pressure Plasmas and their Applications IV

Time: Wednesday 16:30–18:30 Location: WW 1: HS

Invited Talk P 18.1 Wed 16:30 WW 1: HS

Diffusion of reactive species in aqueous solutions treated by a humid atmospheric pressure plasma jet — •Steffen Schüttler, Emanuel Jess, and Judith Golda — Plasma Interface Physics, Ruhr-University Bochum, Universitätsstraße 150, 44801 Bochum, Germany

Plasma-treated liquids are used in various fields such as plasma medicine or plasma-assisted biocatalysis. Atmospheric pressure plasma jets are suitable for production of reactive species such as H2O2 and introducing them into liquids under very good control [1]. The use of reactive species in the liquid requires their solubility and transport through the liquid. In this work, the delivery of reactive species from a humid atmospheric pressure plasma jet into a liquid and the diffusion of OH and H2O2 in the plasma-treated liquid were investigated. The capillary plasma jet used is comparable to the COST reference jet and was operated in humid He. UV absorption was used to measure H2O2 in the liquid, the distribution of OH was visualised by the chemiluminescence of luminol and particle imaging velocimetry (PIV) was used to study convective transport. At low gas flow rates, diffusion of H2O2 through the liquid was measurable, whereas at high gas flow rates, convective transport dominates. In all treatments studied, OH was found to be present mainly at the liquid surface, even at high gas flow rates.

This work is supported by the DFG within CRC1316 (Subproject B11, project number 327886311).

[1] Schüttler et al., Plasma. Process Polym. 2023, e2300079

P 18.2 Wed 17:00 WW 1: HS

Hyperspektrale Untersuchungen von Reaktionen an Plasma-Flüssigkeit-Grenzflächen — •Daniel Tasche[1,2], Kai Bröking[1,2], Christoph Gerhard[1,3] und Wolfgang Viöl[1,2,4] — [1]HAWK Hochschule für angewandte Wissenschaft und Kunst, Fakultät Ingenieurwissenschaften und Gesundheit, Göttingen, Deutschland — [2]Technische Universität Clausthal, Fakultät für Natur- und Materialwissenschaften, Clausthal-Zellerfeld, Deutschland — [3]Politecnico di Milano, School of Industrial and Information Engineering, Mailand, Italien — [4]Fraunhofer-Institut für Schicht- und Oberflächentechnik IST - Anwendungszentrum für Plasma und Photonik, Göttingen, Deutschland

Mittels hyperspektraler Bildgebung können physikalische und chemische Vorgänge spektral, zeitlich und räumlich aufgelöst werden. Hierbei wird das Spektrum einer Szene mittels eines abbildenden Spektrographen aufgezeichnet. Die auf den Spektrographenspalt abgebildeten räumlichen Details bleiben über das gesamte optische System erhalten. Bei der plasmainduzierten Bildung von Silbernanopartikeln werden im violetten Spektralbereich lokale Informationen über Partikeleigenschaften und Bildungsraten zugänglich [1]. Durch Nutzung weiterer Wellenlängenbereiche erhält man Informationen über das Plasma und den optischen Einfluss des Mediums, in dem die Reaktion stattfindet. Damit wird die Möglichkeit gegeben, die Prozesse an der Grenzfläche genauer zu verstehen.

[1] Tasche et al., Nanomaterials 2020, 10, 555.

P 18.3 Wed 17:15 WW 1: HS

Impact of admixtures of H2O on the properties of a He jet plasma — •Tao Zhu[1], Margarita Baeva[1], Florian Sigeneger[1], Peter Bruggeman[2], and Shubham Dongawar[2] — [1]Leibniz Institute for Plasma Science and Technology, Greifswald, Germany — [2]Department of Mechanical Engineering, University of Minnesota

Low temperature He plasma containing admixtures of H2O is currently investigated by modelling and experiments related to plasma catalysis in confined spaces in automotive exhaust. The RF plasma jet is operated in a capillary at atmospheric pressure at a power of a few watts. A global model describes the plasma chemistry and the gas heating. The model is extended to a plug flow model, which converts the temporal evolution of a volume element flowing with the gas into a spatial distribution. A power density profile is defined in the active region between the RF electrodes. This model provides the species densities, the electron mean energy and gas temperature. Experiments based on laser induced fluorescence deliver the density of OH radicals and the gas temperature. A fair agreement was found between modelling and experiments for two power values. The model delivered values of about 5e18 m-3 for the electron density and about 2.5 eV for the electron mean energy which are hardly influenced by the H2O admixture. The analysis of the dominant gain and loss processes of OH revealed pronounced changes of contributions from electron and heavy particle reactions depending on the power.

This work was supported by the DFG-NSF project 509169873.

P 18.4 Wed 17:30 WW 1: HS

Effect of PAW on Rice Seedling Growth and the Expression of Related Genes — Junwei Guo, Dan Zhang, Cheng Yang, and •Huang Feng — College of Science, China Agricultural University, Beijing 100083, China

In plasma agriculture, plasma activated water (PAW) has been shown to improve seed germination, plant growth and resistance to abiotic and biotic stress [1-2]. Due to the complex regulatory mechanism of PAW promoting plant growth, the molecular level hasn't been fully clarified. In this study, RNA-seq was used to analyze the expression levels of related genes after using PAW in rice seedling growth and real-time quantitative PCR was used to verify the expression levels. The key synthetic genes involved in the stress response of rice seedlings to PAW were identified. References [1] Judée, F., Simon, S., Bailly, C., & Dufour, T. (2018). Plasma-activation of tap water using DBD for agronomy applications: Identification and quantification of long lifetime chemical species and production/consumption mechanisms. Water Research, 133, 47-59. [2] Lukacova, Z., Svubova, R., Selvekova, P., & Hensel, K. (2021). The effect of plasma activated water on maize (Zea mays L.) under arsenic stress. Plants, 10(9), 1899.https://doi.org/10.3390/plants10091899

P 18.5 Wed 17:45 WW 1: HS

The ring-shaped spatial distribution of argon excimer, Ar_2^*, in the effluent of the kINPen-Sci — •Andy Nave, Jente Wubs, Philipp Mattern, and Jean-Pierre van Helden — Leibniz institute for Plasma Science and Technology (INP), Felix-Hausdorff-Str. 2, 17489 Greifswald, Germany

The argon excimer (Ar_2^*) species is considered to play an important role in the chemistry of cold atmospheric plasma jets (CAPJs), notably in the formation of reactive oxygen and nitrogen species (RONS). In the present work, we demonstrate that cavity ring-down spectroscopy (CRDS) can be used to detect and quantitatively measure Ar_2^* in the effluent of a cold atmospheric plasma jet, the so-called kINPen-Sci. The spectroscopic features of the $5p\pi\,^3\Pi_g \leftarrow a\,^3\Sigma_u^+$ $\Delta\nu = 0$ and $7p\sigma\,^3\Sigma_g^+ \leftarrow a\,^3\Sigma_u^+$ (ν' - ν'') systems were clearly identified allowing unambiguous assignment to the Ar_2^* species.

Moreover, spatially resolved measurements allowed to distinguish two distinct Ar_2^* populations in the effluent of the kINPen-Sci: a Gaussian and a toroidally shaped distribution. The production mechanisms of these populations seem to differ. On the one hand, a strong correlation was found between the Gaussian Ar_2^* population and the spatial distribution of the filaments produced in the effluent of the kINPen-Sci. On the other hand, the mechanism of formation of the toroid Ar_2^* population remains unclear. However, further measurements were performed while varying the experimental conditions under which the kINPen-Sci was operated. It was found that gas flow velocity must play a major role in the formation of the toroid Ar_2^* population.

P 18.6 Wed 18:00 WW 1: HS

Durability of metal-organic-frameworks (MOFs) in non-equilibrium atmospheric pressure plasmas — •Alexander Quack[1], Hauke Rohr[2], Kerstin Sgonina[1], Norbert Stock[2,3], and Jan Benedikt[1,3] — [1]Institute of Experimental and Applied Physics, Kiel University — [2]Institute of Inorganic Chemistry, Kiel University — [3]KINSIS, Kiel University

Metal-organic-frameworks (MOFs) have a high porosity and large surface area, which gives them potential catalytic properties. Nevertheless, MOFs mostly can not withstand high temperatures and pressures, which are needed in classical catalytic reactions. Non-equilibrium atmospheric pressure plasmas provide reactive and internally excited species and allow for plasma assisted catalysis at lower temperatures. For these processes MOFs can be used as a catalyst if they withstand the plasma conditions.

We have developed a DBD reactor (21 kHz, 16 kV_{pp}) to determine the stability and suitability of different MOFs for plasma assisted catal-

ysis. Reactive plasmas using gas mixtures based on N_2, H_2 and CO_2 gases and in-plasma treatment under externally controlled temperature up to 200 °C have been applied to several MOFs including ZIF-8, ZIF-67 and MAF-6. The plasma exhaust is analyzed for chemical products like NH_3 or CH_4 using a quadrupole mass spectrometer. Additionally, the structural and chemical stability of the MOFs is examined with methods like XRD and FTIR. The results of both measurements are combined to judge the stability and suitability of the different MOFs and their chemical components for in-plasma catalysis applications.

P 18.7 Wed 18:15 WW 1: HS

Elucidating heat transfer occurring during the interaction of a helium jet with ambient air — •Bruno Honnorat[1], Fellype do Nascimento[2], Konstantin Georgiev Kostov[2], and Torsten Gerling[1,3] — [1]ZIK plasmatis, Leibniz Institute for Plasma Science and Technology (INP), 17489 Greifswald, Germany — [2]Faculty of Engineering in Guaratinguetá, São Paulo State University-UNESP, Guaratinguetá 12516-410, Brazil — [3]Diabetes Competence Centre Karlsburg (KDK), Leibniz Institute for Plasma Science and Technology (INP), 17495 Karlsburg, Germany

One of the simplest experimental setup imaginable, which consist of injecting helium at ambient temperature (Tamb) into air at Tamb, with a flow rate of a few SLM, leads to an extraordinary phenomenon. Without plasma discharge, the gas temperature rises by several degrees Kelvin. The underlying physics of this observation remained unclear. The Dufour effect is a thermodynamic phenomenon where a concentration gradient causes heat transfer. This study quantifies the contribution of the Dufour effect on helium jet temperatures. Order-of-magnitude calculations confirm the relevance of the Dufour effect. 2D-axisymmetrical laminar CFD simulations were done with OpenFOAM for different gas flows and gas composition. A fiber optic sensor was moved in the outstream of the jet to realize a 3D map of the temperature. Beside helium, argon and nitrogen jet temperatures were measured. The results show temperature increase in the center of up to 9.4 K and a radial cooling down by 8.4 K. The confrontation of simulations and experiments shows a good agreement.