International Low Temperature Plasma Community

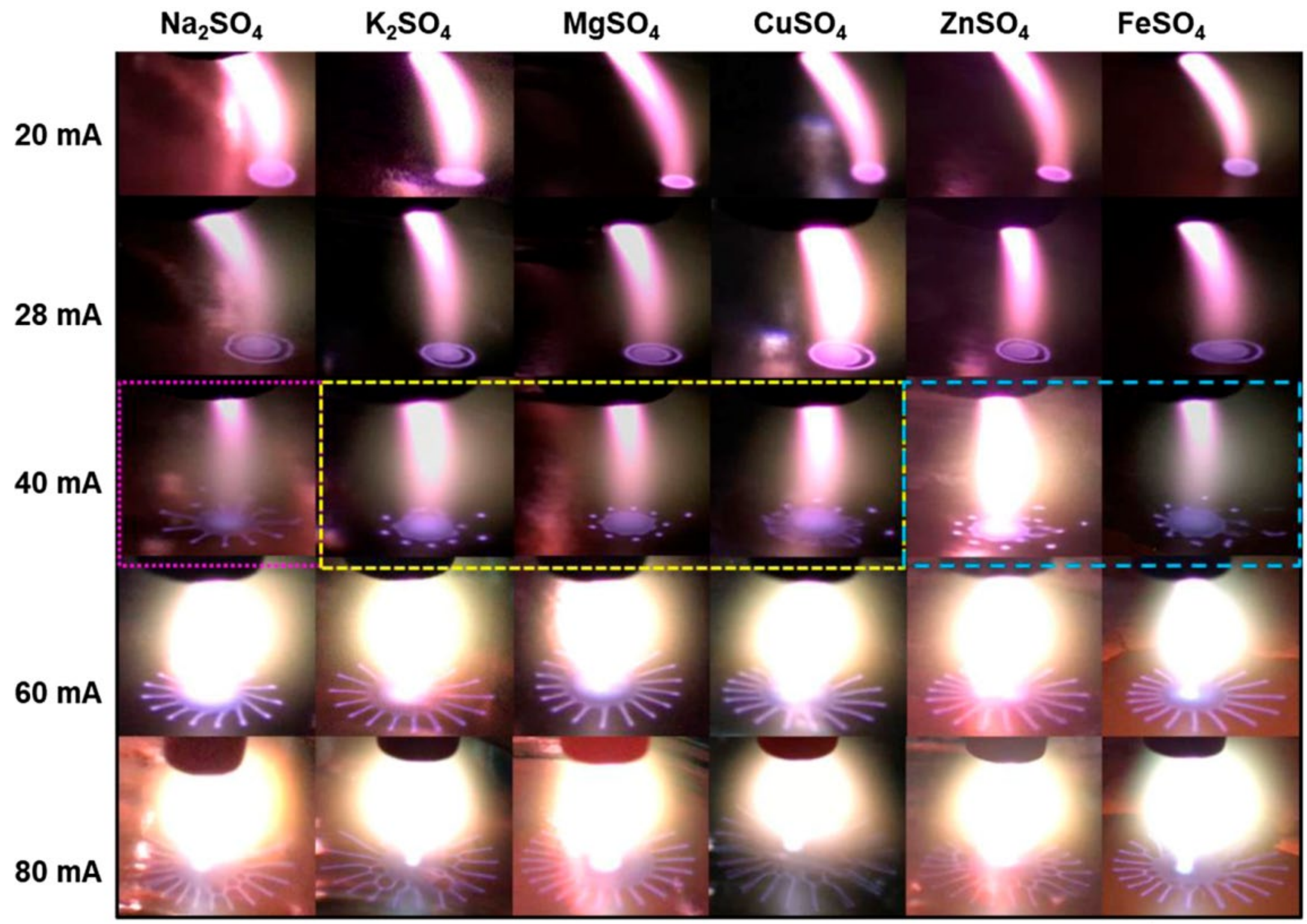
https://mipse.umich.edu/iltpc.php, iltpc-central@umich.edu

Newsletter 13

3 May 2021

Images to Excite and Inspire!

Thank you for submitting your images, some of which are shown here. Those images already submitted will appear in later Newsletters. Please do send your images (with a short description or source) to iltpc-central@umich.edu. The recommended image format is JPG or PNG; the minimum file width is 800 px.



Plasma self-organization on anode surfaces in 1 atm DC glow discharges remains poorly understood. The nature of self-organization on liquid anode surfaces with several different electrolytes was investigated and was found to be a function of discharge current and solution ionic strength. Observed pattern characteristic length scales for self-organization for all of the electrolytes ranged from 2 to 13 mm and typically increased with current for 20–80 mA. Complex self-organized pattern structures not reported to date were also observed. Here pattern variation with increasing current is demonstrated for sulfate based solution groups. Similar pattern behavior at 40 mA is shown by the dashed boxes.

Contacts: **Prof. John E. Foster** and **Dr. Yao Kovach,** University of Michigan, jefoster@umich.edu, yaok@umich.edu.

https://iopscience.iop.org/article/10.1088/1361-6595/abc815/meta

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Call for Contributions

Please submit content for the next issue of the Newsletter. Please send your contributions to iltpc-central@umich.edu by **May 30, 2021**.

Please send contributions as MS-Word files if possible – and **avoid sending contributions as PDF files**.

In particular, please send **Research Highlights and Breakthroughs** using this ***template:*** https://mipse.umich.edu/iltpc/highlight_template_v05.docx. The highlight consists of an image and up to 200 words of text; please also send your image as a separate file (the recommended image format is JPG or PNG; the minimum file width is 800 px). The topic can be anything you want - a recently published work, a new unpublished result, a proposed new area of research, company successes, anything LTP-related. Please see the *Research Highlights and Breakthroughs* for examples.

LTP Perspectives: Policy, Opportunities, Challenges

Contributing to Change in the Low Temperature Plasma Community

What motivates you to study plasmas? Perhaps you are passionate about solving global energy problems and think that LTPs provide solutions through materials synthesis, or catalysis? Perhaps you see the immense promise of plasma-liquid/air/surface interactions for purification and sterilization? No matter the reason, the best way to discover, innovate, and create global change is to leverage the intellect and creativity of the most talented individuals you have access to.

By now, you probably know that this means including people from every possible background and identity - increasing diversity means accessing a broader range of perspectives, raising the potential for groundbreaking discoveries. This is why increasing diversity in the LTP research community is so important. And it's also why it cannot be left to other people alone to increase diversity or improve equity and inclusion (DEI) in our community – you have a stake in this endeavor. You don't have to dedicate your whole career to DEI. Just making a few – or even one – small contribution can have ripple effects that work to everyone's benefit. Consider trying one or two of the following suggestions:

1. **Speak to young people**: When planning your outreach and education efforts, include events at high schools or for first- and second-year college students. As education level goes up, participation from women, students of color, and other sectors of diversity declines. As LTPs are fascinating and engaging, outreach at pre-graduate school levels can help entrain individuals from these groups to join the field.
2. **Become an ally**: Speak up when you see or hear inappropriate behaviors or comments, even if you aren't the target. Maybe it's a joke uttered at an informal gathering, maybe it's a comment at a faculty meeting, or maybe it's gendered language in the notes of a computational code. These little moments have a big impact on whether people feel welcome in a community.
3. **Be a sponsor**: When considering nominations for awards or recognition, make sure you consider colleagues and students from underrepresented groups. They may not have the spotlight as much as individuals from better-represented sectors, but their contributions are just as valuable, so help them share some of that spotlight.
4. **Welcome newcomers:** At meetings and conferences, be as welcoming as possible by focusing on the science, not on the person. When asking a question, be kind. You probably remember your first research conference and how terrifying the Q&A can be. Remember that feeling when you pose your own questions.
5. **Honor codes of conduct:** Develop, implement, and remind people of codes of conduct at meetings and events. Many larger-scale conferences already have codes of conduct, but they can be implemented at faculty meetings and in courses, too. Simply referring to these codes at the start of a meeting can influence behaviors that make it more welcoming.

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Prof. Scott Baalrud, University of Michigan, USA, baalrud@umich.edu

Leaders of the LTP Community: Career Profiles

Professor Kunihide Tachibana – From Swarms and Microplasmas to Societal Leader


10 years ago at Ehime University


Present at a farm

Professor Kunihide Tachibana, who is now Professor Emeritus of Kyoto University (KU) and Osaka Electro-Communication University (OE-CU), has given us a career rich in research activities and educational experiences. The footprints of his impact are evident not only at KU and OEUC but also at the Kyoto Institute of Technology and Ehime University. Among our international colleagues, he is recognized as an intellectual leader from his participation and leadership of a number of international conferences and societies. This is especially true of the International Plasma Chemistry Society (IPCS), where he served as a president and established the archives of International Symposium on Plasma Chemistry (ISPC). Prof. Tachibana was also a co-founder of the International Workshop on Microplasmas (IWM), while also hosting the inaugural meeting (2003) in Japan. His service to the scientific community in Japan has been hugely impactful. Establishing the Division of Plasma Electronics in the Japan Society of Applied Physics in 1990 was one of Prof. Tachibana's prominent achievements. In the latter part of his tenure as president of OECU, he devoted his efforts to developing a new educational methodology for realizing his concept of active learning through four steps: Opportunity → Experience → Capability → Utility.

At the beginning of his research activities in the 1970s and 1980s, Prof. Tachibana provided us with the fundamental parameters of electron-neutral collisions obtained by using electron swarm-experiments. He started in this field following collaborations with Prof. A. V. Phelps at his laboratory at JILA (Joint Institute for Laboratory Astrophysics) at the University of Colorado. Prof. Tachibana's research area expanded to cover plasma chemistry to provide fundamental understanding of plasma material processing (PECVD, RIE, etc.). He and his colleagues and students developed techniques to measure reactive species in these systems utilizing *in-situ* optical (from the VUV to microwave) and mass spectroscopic diagnostics. Another notable achievement was his observation of Coulomb-crystal formation in dust-growing plasmas by Mie-scattering ellipsometry. For five years from 2003, Prof. Tachibana conducted a collaborative project in Japan (informally called the *Tachibana School*) to create the new field of micro-plasmas, i.e., small-scale low-temperature plasmas (LTPs) in high-pressure or high-density media.

Prof. Tachibana is an excellent experimentalist and could often be found performing experiments in his laboratories with his students. (Tachibana-sensei is well known as being a very good teacher in experimental techniques). As a *lifelong experimentalist*, he continued to perform experiments into his 70's with his own handmade apparatuses. After his full retirement, he continues to apply his experimental expertise to vegetable farming and new methods of preparing those vegetables. Another astonishing fact for us is his excellent memory of his fruitful interactions with his many friends and acquaintances in LTP society. When we return to meetings after the pandemic, we encourage you to seek out Prof. Tachibana, a *lifelong experimentalist*, to discuss your research and learn of the impact of his many contributions.

Prof. Osamu Sakai, University of Shiga Prefecture, Japan, sakai.o@e.usp.ac.jp
Prof. Keiichiro Urabe, Kyoto University, Japan, urabe.keiichiro.3x@kyoto-u.ac.jp

General Interest Announcements

- **Plasma Hack Week Organized by the PlasmaPy Project**

  PlasmaPy (http://plasmapy.org) is a collection of computational tools and functionality commonly used and shared between plasma physicists and researchers globally, running within and leveraging the open source scientific Python ecosystem. As part of the outreach for the PlasmaPy Project, we announce the **Plasma Hack Week**.

  The inaugural **Plasma Hack Week** will be held remotely from June 28 – July 2, 2021. A hack week is a mixture of a hackathon (where coders meet and work on programming together for an extended period) and a summer school. Tutorials will be held on topics such as Python, git & GitHub, contributing to an open source project, and writing clean scientific software.

  The Plasma Hack Week itself will have both structured learning activities such as tutorials as well as unstructured project time. This week will be a chance to:

  - Learn how to contribute to an open source project
  - Learn new software development skills with peers
  - Network with fellow plasma students and researchers who are engaging in software development
  - Meet fellow students and scientists who are engaging in programming
  - Collaborate on adding a new feature to an existing software project
  - Add tests and/or documentation to an existing package; and/or
  - Write use cases and user stories to support software projects

  Please see https://hack.plasmapy.org to learn more about the PlasmaPy project, Plasma Hack Week and to register for the **free event!**

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- **National Science Foundation Engineering Research Visioning Alliance**

  The U.S. National Science Foundation (NSF) announces the launch of the *Engineering Research Visioning Alliance* (ERVA), a new organization that will convene the engineering community to identify important engineering research challenges and opportunities. "Engineering has the power to transform people's lives, especially when it brings to bear a diversity of knowledge, perspectives, and experience to solve important problems," says NSF Assistant Director for Engineering Dawn Tilbury. "With NSF's support, the Engineering Research Visioning Alliance will enable the engineering community to mobilize and make a difference in our country's future."

  ERVA will obtain and integrate input on nascent opportunities and priorities in fundamental engineering research. ERVA will engage the engineering research community, including people and organizations in academia, government and industry, as well as professional organizations and the interested public. Building on community ideas, ERVA will share compelling visions for future engineering research to address national needs and societal challenges, leading to positive impacts on people's lives.

  The engineering community can get involved with ERVA and learn about its upcoming visioning activities at https://www.ervacommunity.org/.

Meetings and Online Seminars

- **Online LTP Seminar (OLTP)**

  The Online Low Temperature Plasma (OLTP) Seminar series schedule is available at: https://mipse.umich.edu/ltp_seminars.php. The next seminars will be presented by Dr. Gerjan Hagelaar (**May 11, 2021**); Dr. Jean-Paul Booth (**May 25, 2021**); and Prof. David Graves and Dr. Malcolm Carroll (**June 8, 2021**).

- **International Online Plasma Seminar (IOPS)**

  The International Online Plasma Seminar (IOPS) is a non-profit international seminar on low temperature plasma science with bi-weekly sessions via Zoom. The main purpose of the seminar is to make high quality research results in low temperature plasma science available to our community to foster scientific discussion. Based on the speaker's written consent, presentations will be recorded and will be made available for on-demand download. IOPS speakers can be nominated by anybody and are selected by the IOPS committee. The program for IOPS is available at: https://mipse.umich.edu/online_seminars.php. Nominations for speakers for future speakers can also be made from this page.

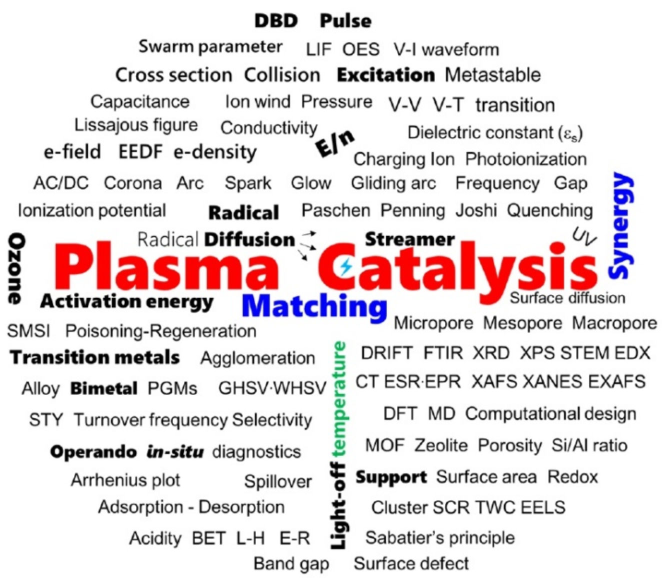
  The next seminars will be given by Dr. Dirk Hegemann (**May 6, 2021**); Brayden Myers and Tat Loon Chng (**May 20, 2021**); and Dr. Matt Hopkins (**June 6, 2021**).

  To attend IOPS, use the following Zoom link:
  https://ruhr-uni-bochum.zoom.us/j/93889931395?pwd=bFN5dU14RHRMYU5ySW40V1gvbDJpZz09

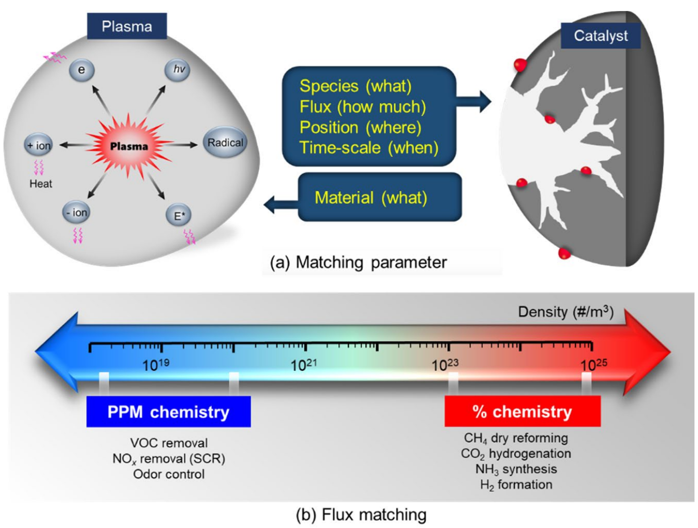
Community Initiatives and Special Issues

Submit your announcement for Community Initiatives and Special Issues to iltpc-central@umich.edu.

Interim Report on Plasma Catalysis: Footprints in the Past and Blueprints for the Future



Important keywords in plasma catalysis widely found in the literature.



Matching between plasma and catalyst: (a) matching parameter, (b) flux matching.

Interactions at the interface of the plasma and catalyst surface have the potential to open new chemical pathways that have never been realized with conventional plasma alone or catalyst-only processes. Plasma catalysis is now facing a rapid growth phase after a long, gradual period of growth over several decades. This interim report aims to analyze the progress of plasma catalysis over the last two decades and provide future challenges.

The first part of the report addresses five important matching issues for plasma and one for catalyst. We collectively present experimental evidence in the literature that underpins the interaction of plasma with a catalyst. We also emphasize synergy, which is sometimes not appreciated by neglecting the heating that occurs with high energy input. In the second part, we discuss recent achievements. A review of the historical development of plasma reactors from a packed-bed to a honeycomb discharge, which are suitable for large-scale applications, is provided.

In the final part, blueprints for future challenges are presented based on the experimentally observed evidence from macro- to nano- and atomic-scale measurements. Developing effective catalysts capable of utilizing vibrationally excited hot molecules will be key for forthcoming innovations in plasma catalysis. We also underline the importance of implementing new sets of materials by introducing recent notable examples in conventional catalysis.

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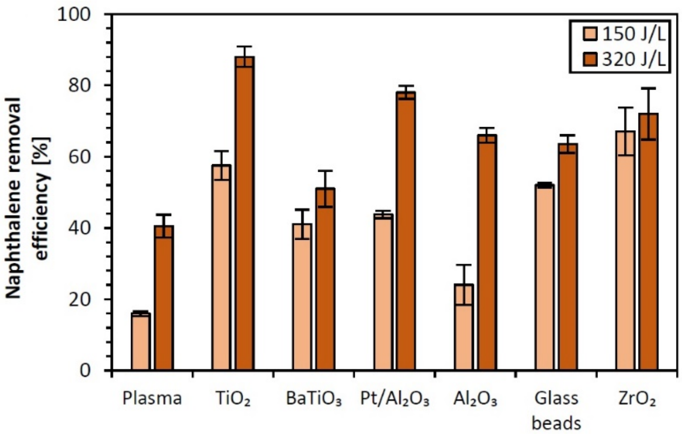
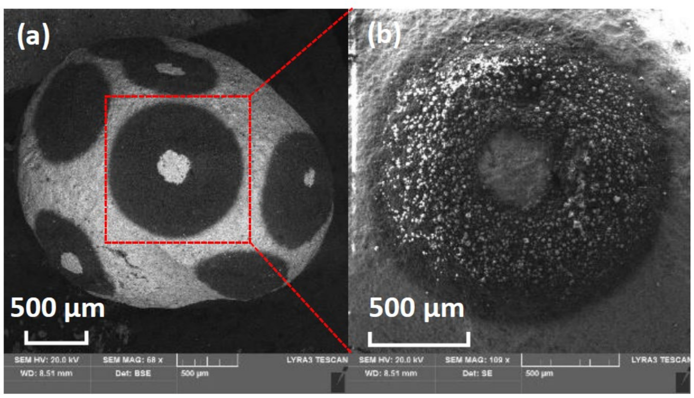
Source:
Int. J. Plasma Environ. Sci. Technol. **15**, e01004 (2021)
https://doi.org/10.34343/ijpest.2021.15.e01004

The Effect of Packing Material Properties on Tars Removal by Plasma Catalysis



Naphthalene removal efficiency for plasma catalytic reactors with various packing materials for the SIE of 150 and 320 J/L.



SEM images of solid carbon deposits of circular patterns on $BaTiO_3$ surface after plasma catalytic naphthalene removal.

Plasma catalysis has been utilized in many environmental applications for removal of various hydrocarbons including tars. The aim of this work was to study the tars removal process by atmospheric pressure DBD non-thermal plasma generated in combination with packing materials of various composition and catalytic activity (TiO_2, Pt/Al_2O_3, $BaTiO_3$, Al_2O_3, ZrO_2, glass beads), dielectric constant (5–4000), shape (spherical and cylindrical pellets and beads), size (3–5 mm in diameter, 3–8 mm in length), and specific surface area (37–150 m^2/g). Naphthalene was chosen as a model tar compound. The experiments were performed at a temperature of 100°C and a naphthalene initial concentration of approx. 3000 ppm, i.e., under conditions that are usually less favorable to achieve high removal efficiencies. For a given specific input energy of 320 J/L, naphthalene removal efficiency followed a sequence: TiO_2 > Pt/Al_2O_3 > ZrO_2 > Al_2O_3 > glass beads > $BaTiO_3$ > plasma only. The efficiency increased with the increasing specific surface area of a given packing material, while its shape and size were also found to be important. By-products of naphthalene decomposition were analyzed by means of FTIR spectrometry and surface of packing materials by SEM analysis.

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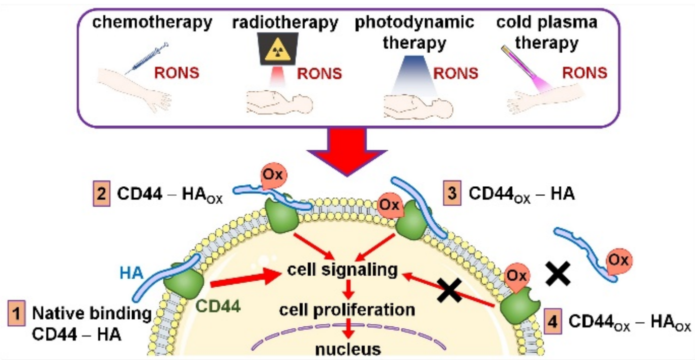
Source:
Catalysts **10** (12), 1476 (2020)
https://doi.org/10.3390/catal10121476

Oxidative Damage to Hyaluronan–CD44 Interactions as an Underlying Mechanism of Action of Oxidative Stress-inducing Cancer Therapy



The four different scenarios of CD44 – HA interaction. 1) Native CD44 and HA interact at the cell surface of cancer cells, promoting cell proliferation. 2) The oxidation induced by NTP in HA and 3) CD44 slightly destroys the interaction. 4) When NTP oxidizes both CD44 and HA, there is a significant decrease in the binding free energy, which translates into a decrease in cell proliferation.

Multiple cancer therapies, including non-thermal plasma (NTP), rely on oxidative stress to damage cancer cells. In this study, we investigated the biological and molecular effects of oxidative stress on the interaction between the cell adhesion receptor CD44 and hyaluronan (HA), as interrupting their binding can hinder cancer progression.

Our experiments demonstrated that following NTP treatment, HA oxidized and decreased its recognition by CD44. This effect was further enhanced when both CD44 and HA were oxidized. The reduction of CD44–HA binding negatively affected the proliferative state of three cancer cell lines (U87-MG, A375 and HT29).

Our multi-level atomistic simulations revealed that the binding free energy of HA to CD44 decreased upon oxidation by NTP treatment. The effect of HA and CD44 oxidation on CD44–HA binding was similar, but when both HA and CD44 were oxidized, the effect was much larger, in agreement with our experiments.

Our experiments and computations support our hypothesis on the role of oxidation (such as produced by NTP) in the disturbance of CD44–HA interaction, which can lead to the inhibition of proliferative signaling pathways inside the tumor cell to induce cell death.

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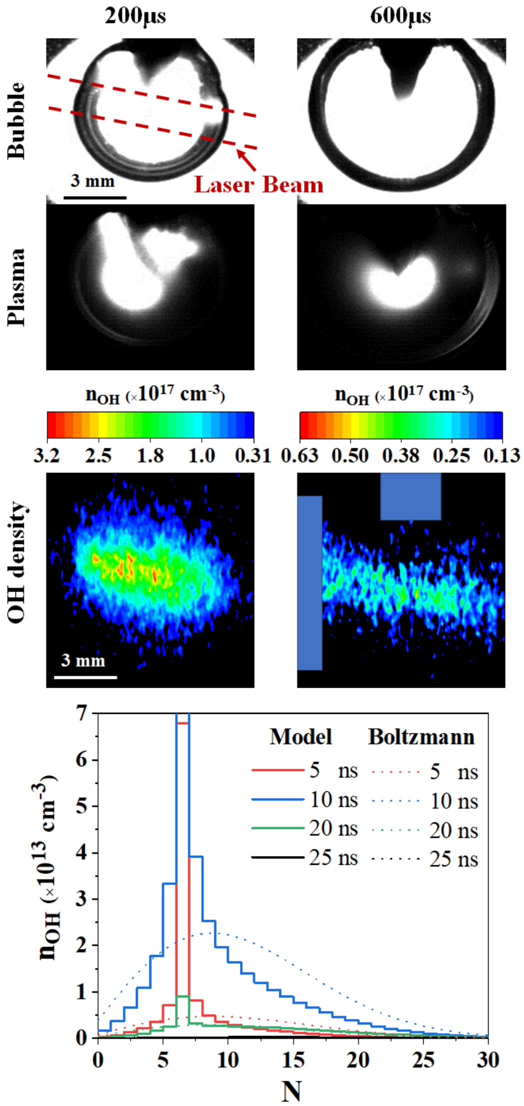
Source:
Redox Biol. **43**, 101968 (2021).
https://doi.org/10.1016/j.redox.2021.101968

Absolute OH Radical Density Measurements in a Plasma-filled Vapor Bubble in Liquid Water



(Top) Shadowgraph and image of the plasma-filled vapor bubble. (Middle) OH density profile in the vapor bubbles along the laser beam. (Lower) Rotational population distributions assuming a thermal gas mixture as obtained by a LIF model. A Boltzmann distribution with the same total OH radical density for each vibrational level is added for comparison. The density of OH(A) (N=6, t=10 ns), the rotational level pumped by the laser at the moment of highest laser intensity, exceeds the plot area and is 25.8×10^{13} cm^{-3}.

Electrical discharges in bubbles in liquid water have been extensively investigated for many applications including water treatment. Often the OH radical is assumed to be a key enabler of many applications although direct measurements of OH radicals in bubbles remained elusive.

Researchers at the University of Minnesota used laser induced fluorescence (LIF) to measure OH radical densities and gas temperatures in a microsecond pulsed discharge generated in a water vapor bubble in a Hele-Shaw cell. The millimeter sized plasma-filled vapor bubble enabled probing by a laser beam and fluorescence signal could be collected during a significant part of the discharge period and coinciding bubble dynamics.

The high collisional conditions and strong collisional quenching of the laser-pumped level made the absolute calibration and gas temperature measurement exceptionally challenging. A rotational level resolved LIF model, capturing the highly non-equilibrium rotational population distributions of the laser excited rotational manifold enabled us to analyze the LIF data and obtain accurate gas temperatures and OH densities. The results show that the gas temperature in the bubble has a maximum value of 4900 ± 800 K and the absolute OH density reaches a value of 3.2 ± 0.5×10^{17} cm^{-3} corresponding to an OH mole fraction of more than 20%. The obtained OH radical densities are consistent with a thermal dissociation model of H_2O in the vapor bubble.

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Source:
https://doi.org/10.1088/1361-6595/abf71c

New Resources

Submit your announcement for New Resources to iltpc-central@umich.edu.

Career Opportunities

- **PhD Position, Methane Upgrading by Ultra-Fast Plasma Pyrolysis, Maastricht University (The Netherlands)**

  We seek PhD candidates to work on methane upgrading using fast-pulsed microwave generated plasma. The research will be primarily by experimental – the candidate will perform product gas analysis combined with state-of-the art laser diagnostics to develop a comprehensive understanding of the underlying physical and chemical processes occurring in the plasma.

  Project description: The chemical industry urgently needs to cut its CO_2 emissions. *Electrification* will reduce emissions from processes by powering them with renewable electricity in place of fossil fuels. *Circular processes* will reuse valuable resources (e. g. plastics), and in doing so will cut end-of-life emissions and reduce resource depletion rates. We research novel *plasma technologies* to facilitate both electrification and circular processes for the chemical industry. In future, industry expects to have an environmentally sustainable source of methane, which can be most effectively valorised via upgrading to ethylene; a crucial feedstock in the production of plastics. However, methane-to-ethylene conversion is notoriously difficult, as it a strongly endothermic reaction with highly complex chemistry. Thermal plasma technology is a promising approach for methane to ethylene conversion as it allows the possibility for high efficiency, excellent reactant conversion, and refined product selectivity.

  In this project, we use microwave generated plasma to induce ultra-fast heating and quenching of methane and its reaction products, at rates around 10^6 – 10^8 K/s. With such ultra-fast heating and quenching, we can induce thermal decomposition of methane and freeze the reaction products before further chemistry has time to occur. There is a short window of opportunity where highly selective conversion of methane to ethylene should be possible. In this project we will evaluate this *window of opportunity* – this requires temporally and spatially resolved in-situ measurements, a task which is ideally suited to laser diagnostics. We will assess the chemistry occurring within the plasma, from which we will determine – is it possible to selectively produce ethylene by ultra-fast thermal plasma processing of methane?

  The PhD position will mainly focus on engineering and studying on-chip micro-plasmas by fast imaging methods, spectroscopy techniques and modelling. The student will work in close cooperation with world leading team of Photonics from Ghent University. We are looking for candidates with a MSc degree in electrical engineering or applied physics. A good background in photonics or plasma physics, spectroscopy, or good experimental skills are desirable. The PhD student will be able to gain experience in areas such as chip design, clean room processing, plasma physics, plasma generation, optical imaging, and UV spectroscopy.

  For more information and to apply for the position, contact:

  Prof. Tom Butterworth, t.butterworth@maastrichtuniversity.nl
  Prof. Gerard van Rooij, g.vanrooij@maastrichtuniversity.nl
  Maastricht University, The Netherlands

- **Research Associate, Modeling and Simulation of the Impedance Probe in Technical Plasmas, University of Applied Science (Soest, Germany)**

The South Westphalia University of Applied Science offers a Research Associate position for the project "The impedance probe: a possible industry compatible diagnostic tool in metallic depositing plasmas" in the department of Electrical Power Engineering at the campus in Soest, Germany to be filled as soon as possible.

Typical tasks:

- Research and coordination of the project on the Impedance Probe
- Modeling and simulation of the interaction between the impedance probe and the plasma
- Support in project acquisition and proposals
- Publication of results in journal paper and conference contributions
- Documentation of the project via reports

Essential characteristics:

- Above-average completed university degree, especially in the fields of computational engineering or science, electrical engineering, plasma science physics, mathematics, or similar.
- Very good knowledge in plasma physics and/or technical plasmas as well as simulation of electromagnetic fields (ideally in CST).
- Programming experience in at least one language (C/C++, Python, or similar) is expected, knowledge in parallelization is an advantage.
- A high level of proficiency in English language (written and spoken) and a structured and self-organized way of working is expected. Knowledge of German is an asset.
- Further knowledge in kinetic theory, functional analytic methods, and/or solving of large linear systems of equations is an advantage.

Contract conditions:

The full-time position in salary group EG TV-L 13 (100%) is offered for a period of three years. The opportunity for further personal qualification (PhD) is available.

Please apply with the usual documents and a research motivation of 2 pages DIN A4 letter with the keyword **18/2021 only** via the online application page (https://www4.fh-swf.de/cms/stellen/) until **May 31, 2021**.

For information and application details, contact:

Prof. Dr.-Ing. Jens Oberrath

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Collaborative Opportunities

Please submit your notices for collaborative opportunities to iltpc-central@umich.edu.

Disclaimer

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Newsletter is supported by:

US National Science Foundation

US Department of Energy Office of Science

University of Michigan Institute for Plasma Science and Engineering