16th INTERNATIONAL SYMPOSIUM ON PLASMA BIOSCIENCE

ISPB[16]

| 2026

Plasma Science for Sources, Health, Agriculture, Environment & Materials

12 (Wed)– 14 (Fri) August 2026

Kwangwoon University, Seoul, Korea

Plasma Bioscience Research Center (PBRC)

ISPB16

16th International Symposium on Plasma Bioscience

ABSTRACT BOOK

80th Anniversary Building, Conference Hall 310
Kwangwoon University, Seoul, Korea

12 – 14 August 2026
Seoul, Korea

ISPB 2026 Abstract Book

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ISPB2026

Conference Welcome Address

Prof. Eun Ha Choi

On behalf of the Organizing Committee, it is my great pleasure to welcome you to the **16th International Symposium on Plasma Bioscience (ISPB 2026)**, held at **Kwangwoon University, Seoul, Republic of Korea, from August 12–14, 2026**.

ISPB 2026 is proudly organized by **Kwangwoon University**, the **Department of Electrical and Biological Physics**, the **Plasma Bioscience Research Center (PBRC)**, the **Korea Plasma-Bio Industry Association (KPIA)**, and **Plasade Co., Ltd.**

Since its inception in **2011**, ISPB has grown into a premier international forum for plasma bioscience, bringing together researchers, engineers, clinicians, and industry leaders to exchange knowledge and foster global collaboration. We are delighted to celebrate the **16th edition** of this symposium.

This year's scientific program highlights recent advances in plasma medicine, biology, agriculture, environmental engineering, biomaterials, nanotechnology, and related interdisciplinary fields. We hope ISPB 2026 provides an inspiring platform for scientific discussion, innovation, and the development of new international collaborations.

I sincerely thank all speakers, participants, sponsors, exhibitors, and organizing committee members for their valuable support. I hope you enjoy the scientific program, experience the warm hospitality of Seoul, and create lasting professional relationships during your stay.

Thank you for being part of ISPB 2026. I wish you a productive and memorable conference, and I look forward to welcoming you again to the **17th International Symposium on Plasma Bioscience (ISPB 2027)** next year.

With my best regards,

Prof. Eun Ha Choi,
Chairman, ISPB 2026
CEO, Plasade Co., Ltd.
Director, Plasma Bioscience Research Center (PBRC),
Kwangwoon University, Seoul, Republic of Korea

Conference Welcome Address

Prof. Nagendra Kumar Kaushik

It is my great pleasure to welcome you to the **16th International Symposium on Plasma Bioscience (ISPB 2026)** at **Kwangwoon University, Seoul, Republic of Korea**. As an organizer of ISPB 2026, I am delighted to welcome all participants to this exciting international gathering.

This year, ISPB 2026 has attracted **around 100 participants from 12 countries** and features **more than 70 scientific abstracts**, reflecting the growing global interest in plasma science and its interdisciplinary applications. Your enthusiastic participation has made this symposium a truly international forum for scientific exchange and collaboration.

The conference presents the latest advances in **plasma sources and diagnostics**, **plasma bioscience**, **environmental and agricultural applications**, **plasma medicine and healthcare**, **materials engineering**, **nanomaterial synthesis**, **space technology** and many other emerging areas where plasma technologies are driving scientific and technological innovation. I sincerely thank all plenary and invited speakers, session chairs, and members of the organizing committee for their invaluable contributions. Your commitment and support have been essential to the success of ISPB 2026.

I hope you enjoy an inspiring scientific program, productive discussions, and the warm hospitality of Seoul. I wish you a rewarding and memorable conference experience.

With my best wishes,

Prof. Nagendra Kumar Kaushik
Co-Chairman, ISPB 2026
Professor, Department of Electrical and Biological Physics
Plasma Bioscience Research Center (PBRC)
Kwangwoon University, Seoul, Republic of Korea

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Programme at a Glance

	Wednesday, 12 August	Thursday, 13 August	Friday, 14 August
Morning	Plasma-Bio Tutorial	Plenary Lecture Technical Session	Plenary Lecture Technical Sessions
Afternoon	Opening Plenary Lecture Technical Sessions Special Session Poster Session	Conference Tour Plasma Farm Paju DMZ Tour (Imjingak Park)*	Industry Session Poster Session Special Session
Evening	Welcome Reception	Conference Dinner	Awards Closing

Venue: Conference Hall 310, 3rd Floor, 80th Anniversary Bldg.

*Note for Paju DMZ Conference Tour:
Please bring your valid physical passport (or national ID card for Korean citizens). Entry may be restricted without proper identification.
Tour Highlights: Imjingak Peace Park, Bridge of Freedom, Gondola.

Day 1 — Wednesday, 12 August 2026

09:00 – 12:10 | Plasma Bio Tutorial (Session Chair: Prof. Eun Ha Choi / Prof. Nagendra Kumar Kaushik)

Time	Type	Speaker	Title
09:00 – 09:20	**Registration**		
09:20 – 09:30	**Welcome Remarks**	Prof. Eun Ha Choi	Welcome Remarks for Plasma Bio Tutorial
09:30 – 10:00	**Tutorial**	Prof. Eric Robert (CNRS/GREMI/Université d'Orléans, France)	Plasma jet in interaction with targets: the physicochemical impact
10:00 – 10:30	**Tutorial**	Prof. Hiromasa Tanaka (Nagoya University, Japan)	Plasma-Activated Solutions for Cancer Treatment: From Chemistry to Biological Responses
10:30 – 10:40	**Tea Break**		
10:40 – 11:10	**Tutorial**	Prof. Eun Ha Choi (Kwangwoon University, Korea)	Plasma devices for bioscience and agriculture
11:10 – 11:40	**Tutorial**	Prof. Gyungsoon Park (Kwangwoon University, Korea)	Plasma agricultural applications
11:40 – 12:10	**Tutorial**	Prof. Nagendra Kumar Kaushik (Kwangwoon University, Korea)	Plasma cell & tissue interactions
12:10 – 13:20	**Lunch Break**		

13:20 – 15:00 | Technical Session 1 (Wed1) (Session Chair: Prof. Jun-Seok Oh / Prof. Kazunori Koga)			
Time	**Type**	**Speaker**	**Title**
13:20 – 13:30	**Welcome Remarks**	Prof. Eun Ha Choi, Prof. Nagendra Kumar Kaushik	Welcome Remarks for ISPB16
13:30 – 14:00	**Plenary Talk**	Prof. Eric Robert (CNRS/University of Orleans, France)	Do reactive species or others control plasma action in tissues?
14:00 – 14:20	**Invited Talk**	Prof. Hiromasa Tanaka, (Nagoya University, Japan)	Future Prospects of plasma-activated solutions
14:20 – 14:40	**Invited Talk**	Prof. Sun Jung Kim (Dongguk University, Korea)	Cold Atmospheric Plasma-Induced Epigenetic Remodeling: Integrating lncRNA Regulation and m6A RNA Methylation in Cancer Cells
14:40 – 15:00	**Invited Talk**	Dr. Sybille Hasse (Leibniz Institute for Plasma Science and Technology (INP), Germany)	Plasma- Functionalized liquids for Tissue decontamination
15:00 – 15:10	**Tea Break**		
15:10 – 16:30 | Technical Session 2 (Wed2) (Session Chair: Prof. Eric Robert / Prof. Sun Jung Kim)			
Time	**Type**	**Speaker**	**Title**
15:10 – 15:30	**Invited Talk**	Prof. M. S. Roopesh (University of Alberta, Canada)	Enhanced Inactivation of Multispecies Biofilms Using Plasma-Activated Nanobubble Water Combined with UV-C and Hydrogen Peroxide
15:30 – 15:50	**Invited Talk**	Prof. XinPei Lu (Huazhong University of Science and Technology, China)	An ETOP-Based Unified Plasma Dose Framework Incorporating Chemical, Electrical, and Photonic Effects
15:50 – 16:10	**Invited Talk**	Prof. Mudtorlep Nisoa (Walailak University, Thailand)	Engineering a Scalable Plasma-Activated Water System with Tunable Reactive Species for Nitrogen Fixation and Sustainable Agricultural Applications
16:10 – 16:30	**Invited Talk**	Dr. Jihwan Kim,(Baekse Korean Medical Clinic, Korea)	The Dawn of Quantum Therapy and Bio-Therapeutic Applications of Infrared Pearlite Boards
16:30 – 17:20	**Poster Session (2F, 80th Anniversary Bldg.) with Tea Break**		
17:20 – 19:20 | Special Session 1 (Wed3) — Young Researchers Presentation with Panel Discussion (Session Chair: Prof. Hiromasa Tanaka / Dr. Sybille Hasse / Prof. Ashish Ranjan Sharma)			
Time	**Type**	**Speaker**	**Title**
17:20 – 17:35	**Invited Young Researcher**	Dr. Tirtha Raj Acharya (University of Nottingham, United Kingdom)	Low Temperature Plasma-Assisted Synthesis of HCN and CO from C, N2, and H2O for Sustainable Oxamide Fertilizer Production

17:35 – 17:50	**Invited Young Researcher**	Dr. Tejal Barkhade (Parul University, India)	Comparative Investigation of DC and Microwave Plasma Systems for Bacterial Inactivation: Spectroscopic and Microscopic Analysis
17:50 – 18:05	**Invited Young Researcher**	Dr. Kittipit Klanliang, (Chiang Mai University, Thailand)	Antibacterial Efficacy of Plasma-Activated Water Against Enterococcus faecalis Biofilms: An In Vitro and Ex Vivo Study
18:05 – 18:20	**Invited Young Researcher**	Dr. Kochakon Moonsub (ChiangMai University, Thailand)	Engineering Plasma-Activated Hydrogel Conditions for Enhanced Inactivation of Pseudomonas aeruginosa
18:20 – 18:35	**Invited Young Researcher**	Dr. Roshani Dahal (KAIST, Korea)	$ZnFe_2O_4$-Catalyzed Dielectric Barrier Discharge Plasma for Sustainable Degradation of Sulfathiazole in Aqueous phase
18:35 – 18:50	**Invited Young Researcher**	Ms. Lavanya Jayasankar (SRIHER, India)	Effects of Cold Atmospheric Plasma in Head and Neck Squamous Cell Carcinoma Ex Vivo
18:50 – 19:05	**Invited Young Researcher**	Ms. Devi Maigandan (SRIHER, India)	Comparative Evaluation of Plasma Feed Gases on Antimicrobial Activity and Wound Healing Responses in Diabetic Foot Ulcer
19:05 – 19:20	**Invited Young Researcher**	Dr. Apurva Jaiswal (PBRC, Korea)	Nonthermal Plasma-Driven Skin Rejuvenation with Nitric Oxide Water
19:20 onwards	**Welcome Reception (2F, 80th Anniversary Bldg.)**		

Day 2 — Thursday, 13 August 2026

09:00 – 10:10 | Technical Session 3 (Th1) (Session Chair: Prof. Nagendra Kumar Kaushik / Prof. Janardhan Reddy)

Time	Type	Speaker	Title
09:00 – 09:30	**Plenary Talk**	Prof. Masaharu Shiratani (Kyushu University, Japan)	Low-Temperature Plasma as a Gene-Switching Technology: A New Paradigm in Plasma Bio-Science
09:30 – 09:50	**Invited Talk**	Prof. Jun-Seok Oh (Osaka Metropolitan University, Japan)	UV-vis Spectrophotometry for Measuring Plasma-induced Reactive Oxygen and Nitrogen Species
09:50 – 10:10	**Invited Talk**	Prof. Kazunori Koga (Kyushu University, Japan)	Differential Roles of Atomic Oxygen and Ozone in Germination Enhancement and Protein Modification of Rice Seeds
10:10 – 10:20	**Tea Break**		

10:20 – 12:00 │ Technical Session 4 (Th2) (Session Chair: Prof. Masaharu Shiratani / Prof. Gyungsoon Park)			
Time	**Type**	**Speaker**	**Title**
10:20 – 10:40	**Invited Talk**	Prof. Sanghoo Park (KAIST, Korea)	Breaking the Well-Mixed Assumption in Closed Air Plasma Reactors: Thermal Stratification Governs O3-to-NOx Chemistry
10:40 – 11:00	**Invited Talk**	Prof. Wassanai Wattanutchariya (Chiangmai University, Thailand)	From Plasma-Activated Water to Plasma-Activated Hydrogel: Advancing Stable Plasma Therapeutics for Biomedical Applications
11:00 – 11:20	**Invited Talk**	Prof. Le Manh Cuong (Tue Tinh Hospital, Vietnam)	Cold Plasma in Clinical Treatment at Tuệ Tĩnh Hospital, Vietnam
11:20 – 11:40	**Invited Talk**	Prof. Pham Huy Dung (Thang Long University, Vietnam)	Nano-Redox Pathology and Triadic Biological Effects of Cold Atmospheric Plasma: A Theoretical Framework for Translational Plasma Medicine
11:40 – 12:00	**Invited Talk**	Prof. Lakshminarayana Rao (IISc Bangalore, India)	Plasma-Activated Water and Its Application in Medicine and Agriculture
12:00 – 12:20	**Light Lunch Box Distribution and Proceed for Tour Bus**		
12:00 – 18:30	**Conference Tour / Excursion — Plasma Agriculture Farm • Paju DMZ Tour**		
18:30 onwards	**Banquet/Gala Dinner (2F, 80th Anniversary Bldg.)**		

Day 3 — Friday, 14 August 2026			
09:00 – 10:10 │ Technical Session 5 (Fri1) (Session Chair: Prof.Sanghoo Park / Prof. Wassanai Wattanutchariya)			
Time	**Type**	**Speaker**	**Title**
09:00 – 09:30	**Plenary Talk**	Prof. Alexander Fridman (Drexel University, USA)	Non-Thermal Gliding Arcs in Tornado: Scaling Up for Agricultural and Food Processing Applications
09:30 – 09:50	**Invited Talk**	Prof. Keping Yan (Zhejiang University, China)	High Voltage Power Sources for Plasma and Electric field Processing
09:50 – 10:10	**Invited Talk**	Dr. Christian Seebauer (UKSH, Lübeck, Germany)	Cold Atmospheric Plasma as an Adjunctive Preventive and Therapeutic Approach for Radiation Dermatitis: A Observational Case Series
10:10 – 10:20	**Tea Break**		

10:20 – 12:10 | Technical Session 6 (Fri2) (Session Chair: Prof. Hyungyu Lee / Prof. Ravi Gupta)			
Time	**Type**	**Speaker**	**Title**
10:20 – 10:50	**Plenary Talk**	Prof. Wonho Choe (KAIST, Korea)	Unraveling Physicochemical Phenomena in Plasma–Liquid Systems
10:50 – 11:10	**Invited Talk**	Prof. Byung-Wook Yun (Kyungpook National University, Korea)	Nitric Oxide and Redox Signaling in Plants; From Molecular Mechanisms to Plasma-Activated Water
11:10 – 11:30	**Invited Talk**	Prof. Kamatchi Sankaranarayanan (IASST-DST, India)	Cold Atmospheric Plasma Technology for Biomaterials Design: Liquid–Liquid Phase Separation Driven Self-Assembly of Biomolecules
11:30 – 11:50	**Invited Talk**	Prof. Rajesh Gandhirajan (SRIHER, India)	Engineering Reactive Species In Biology: Translational Applications of Cold Atmospheric Plasma Across Plant, Infection, and Cancer Models
11:50 – 12:10	**Invited Talk**	Prof. Han S. Uhm (PBRC, Korea)	Properties of NO in blood and its influence on our health
12:10 – 13:10	**Lunch Break**		

13:15 – 14:30 | Industry Technical Session 7 (Fri3) (Session Chair: Prof. Jang Sick Park / Prof. Eun Ha Choi)			
Time	**Type**	**Speaker**	**Company**
13:15 – 13:30	**Industry Talk**	Prof. Jinsung Choi	Plasade Co., Ltd.
13:30 – 13:45	**Industry Talk**	Mr. Dae Kyu Joo	Bioplatech Co., Ltd.
13:45 – 14:00	**Industry Talk**	Mr. Joon Hyung Bae	Dawoo Korea Co., Ltd.
14:00 – 14:15	**Industry Talk**	Ms. Misun Lee	Cold Pla co., Ltd.
14:15 – 14:25	**Tea Break**		

14:25 – 15:45 | Technical Session 8 (Fri4) (Session Chair: Dr. Nguyen Nhat Linh / Prof. Neha Kaushik)			
Time	**Type**	**Speaker**	**Title**
14:25 – 14:45	**Invited Talk**	Prof. Eun Ha Choi (Kwangwoon University, Korea)	Brief Report of IEC60601-2-91, WG41,TC62D “Particular requirements for the basic safety and essential performance of non-thermal plasma wound treatment equipment”
14:45 – 15:05	**Invited Talk**	Prof. Pradoong Suanpoot (Maejo University, Thailand)	Effect of Atmospheric Pressure Cold DBD Plasma on Seed Germination and Crop Yield of Sticky Rice and White Rice Varieties during the Wet Season
15:05 – 15:25	**Invited Talk**	Prof. Janardhan Reddy Koduru (Kwangwoon University, Korea)	Plasma-Enabled Interfacial Engineering: A Sustainable Pathway Toward Next-Generation Materials

15:25 – 15:45	**Invited Talk**	Prof. Gyungsoon Park (Kwangwoon University, Korea)	Plasma application to soil and hydroponic culture
15:45 – 15:55	**Tea Break**		
15:55 – 17:15 | Technical Session 9 (Fri5) (Session Chair: Prof. M. S. Roopesh / Prof. Mudtorlep Nisoa			
Time	**Type**	**Speaker**	**Title**
15:55 – 16:15	**Invited Talk**	Prof. Jang Sick Park (PBRC, Korea)	Humidity and Temperature Effects on Plasma Chemistry Dynamics in a Parallel-Plate DBD Source
16:15 – 16:35	**Invited Talk**	Prof. Hyungyu Lee (Kwangwoon University, Korea)	Diagnostics and Simulation for Plasma Chemistry
16:35 – 16:55	**Invited Talk**	Dr. Nguyen Nhat Linh (Vietnam Academy of Science and Technology, Vietnam)	Autonomous Synthesis and Materials Informatics in Plasma Technology: Advancing Materials for Energy and Environmental Applications
16:55 – 17:15	**Invited Talk**	Prof. Yung Oh Shin (PBRC, Korea)	Increasing Role of Antiviral Disinfectants in the Control of Emerging Viral Diseases
17:15 – 17:25	**Tea Break**		
17:25 – 19:25 | Technical Session 10 (Fri6) (Session Chair: Prof. Pradoong Suanpoot / Prof. Kamatchi Sankaranarayanan / Prof. Rajesh Gandhirajan)			
Time	**Type**	**Speaker**	**Title**
17:25 – 17:45	**Invited Talk**	Prof. Ashish Ranjan Sharma (Hallym University, Korea)	Plasma-Activated Media Stimulate Osteogenic Differentiation in Osteoblasts via ROS-Mediated WNT Signaling: A Novel Approach for Bone Regeneration
17:45 – 18:05	**Invited Talk**	Mr. JeongKun Ryu (Dr. Yim's Institute of Constitutional lifestyle, Korea)	Sasang Constitution as a Stratification Variable for Inter-Individual Variance in Nitric Oxide Response: Toward Convergence with Plasma-Generated NO Water
18:05 – 18:25	**Invited Talk**	Prof. Umesh Kumar (Chandigarh University, India)	Epigenetic Reprogramming by Curcumin in Cancer: Emerging Opportunities for Precision Oncology and Translational Therapeutics
18:25 – 18:40	**Oral Lecture**	Prof. Ravi Gupta (Kookmin University, Korea)	Proteomic insights into the rice responses to Magnaporthe oryzae
18:40 – 18:55	**Oral Lecture**	Prof. Neha Kaushik (Suwon University, Korea)	Nonthermal Plasma-Mediated Transcriptional Rewiring for Breast Cancer Therapy
18:55 – 19:10	**Oral Lecture**	Prof. Ihn Han (PBRC, Korea)	Plasma- Activated NO water (PNOW) for Sterilisation and Growth Support in Hydroponic Cultivation

19:10 – 19:25	**Oral Lecture**	Prof. Nagendra Kumar Kaushik (Kwangwoon University, Korea)	Plasma-Generated Nitric Oxide Water for Pathogen Control and Skin Cosmetics
19:25 – 19:35	**Awards & Closing Declaration**		
19:35 onwards	**Traditional Local Dinner**		

Notes
* Note for presentation time limits: Tutorial: 30 mins (including Q&A) Plenary Lecture: 30 mins (including Q&A) Invited Lecture: 20 mins (including Q&A) Special Session – Young Researchers: 15 mins (including Q&A) Oral Lecture :15 mins (including Q&A) Industry Session:15 mins (including Q&A)
* Note for poster size limits: Poster must fit within a 0.9 m × 1.8 m poster board space. Standard recommended poster size is 0.9 m (Width) × 1.2 m (Length) (Around A0 size)

Poster Presentations

Day 1 — Wednesday, 12 August 2026

16:30 – 17:20 Poster Session (2F, Lobby, 80th Anniversary Building)

Poster No.	Name	Affiliation	Title
P1	Ms. Anchal Bhatnagar	Kwangwoon University, Korea	Improvement of bacterial enterobactin production by using atmospheric pressure non-thermal plasma
P2	Ms. Lavanya Jayasankar	Sri Ramachandra Institute of Higher Education and Research (SRIHER), India	Effects of Cold Atmospheric Plasma in Head and Neck Squamous Cell Carcinoma Ex Vivo
P3	Ms. Anahita Vispi Bharda	Kwangwoon University, Korea	Exploring Plasma Activated NO Water for Stress Mitigation, Muscle Health and Aging
P4	Mr. Subhadip Mukherjee	Kwangwoon University, Korea	Plasma-Generated Nitric Oxide Water as an Antiviral Strategy Against Vaccinia Virus
P5	Ms. Neha Rana	Kwangwoon University, Korea	Mapping nitrosative hotspots in coronavirus spike glycoproteins for virus inactivation
P6	Mr. Sang-Hyun Cho	Yonsei University, Korea	Surface Modification of β-Tricalcium Phosphate Scaffold by Hydration with Plasma-Activated Solutions
P7	Ms. Wirinthip Ketya	Kwangwoon University, Korea	Analysis for the growth of bok-choy (Brassica rapa subsp. chinensis) in plasma-applied hydroponic culture
P8	Ms. Rakeb Kifle Alemu	Kwangwoon University, Korea	Synergistic Effects of Non-Thermal Plasma and Fungal Pretreatment on Sustainable Bioethanol and Nanocellulose Production using Used Coffee Ground
P9	Mr. Jong Hun Jeong	Kwangwoon University, Korea	Spent granular activated carbon regeneration using peroxydisulfate in Dielectric Barrier Discharge system
P10	Dr. Zaffar Iqbal	Kwangwoon University, Korea	Non-Thermal plasma induced degradation of methyl paraben: Role of hydroxyl radicals and toxicity mitigation
P11	Ms. Ye-Jin Kim	Kwangwoon University, Korea	Development of Treatment Technology for High-Efficiency PFOA Decomposition Using DBD Plasma–NaOCl Hybrid Advanced Oxidation Process
P12	Mr. JaeHyoung Lee	Kwangwoon University, Korea	Ru-loaded on ZIF-67 for improving photocatalytic ammonia production
P13	Dr. Chhakchhuak Vanlalhmingmawia	Kwangwoon University, Korea	Synergy of Nonthermal Plasma and Multifunctional $MnFe_2O_4$/Boron-Doped Graphene Hybrid Catalyst for Efficient Pharmaceutical Wastewater Remediation
P14	Mr. Dhruv Sharma	Kwangwoon University, Korea	Space Pathogens: Survival and Virulence in Crewed Space Missions and Plasma-Based Control Strategies
P15	Ms. Surabhi P Baburajan	Kwangwoon University, Korea	Reactive Species-Driven Degradation of Organic Pollutants Using a Dielectric Barrier Discharge Plasma System

Poster No.	Name	Affiliation	Title
P16	Ms. Devi Maigandan	SRIHER, India	Comparative Evaluation of Plasma Feed Gases on Antimicrobial Activity And Wound Healing Responses in Diabetic Foot Ulcer
P17	Mr. Piyush Verma	Institute of Nuclear Medicine and Allied Sciences (INMAS), India	Potential of ATR-FTIR Spectroscopy and Molecular Parameters in Elucidating Immune Responses Associated with Burn Injury
P18	Prof. Do Young Kim	Co-president, Institute of Future Security Industry Strategy, Korea	Integrated Multi-Layered Security Technologies for Critical Infrastructure Protection: UAV Platforms, AI Surveillance, Counter-UAS and Industrial Cyber Security
P19	Ms. Ananya Chakraborty	Indian Institute of Technology Delhi (IIT Delhi), India	Experimental Characterization of a Dual Dielectric Barrier AC Plasma Jet for Biomedical Applications
P20	Prof. Feng Huang	China Agricultural University (CAU), China	The Self-organizing Behavior in Ethylene Radio Frequency Plasma Discharge
P21	Dr. Shikha Pandey	Indian Institute of Technology Madras, Chennai, India	Analytical Modelling for Predicting Methane Conversion and Hydrogen Yield in Non-Thermal Plasma-Assisted Methane Pyrolysis
P22	Dr. Sanjeet Kumar Paswan	Multi-Functional Plasma Laboratory (MFPL), Department of Energy Science and Engineering, Indian Institute of Technology, Delhi-110016, India	Plasma process for controlled magnetron sputtered tricalcium phosphate films for antimicrobial efficacy for orthopedic implants
P23	Ms. Priya Bhatt	DST-IASST, Guwahati, India	Cold Atmospheric Plasma Technology Enabling Fabrication of Peptide-Based Supramolecular Gels for Potential Electrochemical Applications
P24	Dr. Sushma Jangra	Indian Institute of Technology Jodhpur, India	Atmospheric Pressure Dielectric Barrier Discharge Plasma for Pesticide Remediation in Model Soil: GC-MS Analysis, Degradation Mechanisms, and Toxicity Evaluation
P25	Dr. Pawan Tiwari	Birla Institute of Technology, Mesra, India	Microscopic Plasma Discharges: A Potential application of Plasma Streamers in the Fabrication of Biomedical Plasma Apparatuses
P26	Mr. Rupam Ghosal	Birla Institute of Technology, Mesra, India	Plasma-Mediated AI Enabled Breath Biosensor for Respiratory Disease Diagnostics and Therapeutics
P27	Ms. Riddhima Sadhu	Birla Institute of Technology, Mesra, India	Optical Coherence Tomography: An Emerging Modality in Deep Tissue Imaging
P28	Mr. Saidul Sk	Indian Institute of Technology Delhi (IIT Delhi), India	Engineering and Optimization of a Low Frequency Power Cold Atmospheric Pressure Plasma Jet for Biological Application

PLENARY LECTURES

Plenary Lecture

Do reactive species or others control plasma action in tissues?

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It is obvious that during so-called direct plasma treatments for biomedical applications, the plasma delivery consists in a transient interaction with the upper surface of tissues. Nevertheless, from the pioneer in vivo demonstrations of plasma therapeutic benefits, it is well known but still highly questioning on how such surface plasma interaction may lead to deep tissue response, e.g. regression/ablation [1,2]- apoptosis induction [1]- signaling [3] in subcutaneous tumors, tissue regeneration for thick wounds [4], deep tissue oxygenation [5, 6]…

The presentation first summarizes reactive species generation and electric field features, micro-current characteristics when targets of various nature and relevant for biomedical applications are exposed to plasma jets.

Then in vitro and ex vivo transient permeabilization and localized or distant tissue oxygenation are documented. The presented results illustrate the potentialities of non-thermal plasma exposure for deep, instantaneous, delayed, transient or persisting tissue response and its possible combination with other non-plasma-based therapeutic protocols in oncology or wound care. These plasma triggered biological phenomena are of key interest to develop cosmetic applications with the favoring of active ingredients penetration across the skin barrier. The same holds true for drug delivery for dermatological purposes but also for the recently developed multi jet treatment of skin precancerous lesions, i.e. actinic keratosis. Besides few tens of microns in depth plasma action on skin models or tissues, recent experiments demonstrate and confirm other groups report, for much deeper, on the millimeter range, effect of plasma. This hold promise for other medical applications, as for muscle stimulation in sport medicine for example. Simultaneously this is also highly questioning and probably support that electrostimulation through micro currents and/or electric field delivery across tissues is involved during plasma exposure.

References

[1] M. Vandamme et al, International journal of cancer 130 (9), 2185-2194 (2012)
[2] M. Keidar M et al, Br J Cancer 105: 1295–1301 (2011)
[3] A.G. Lin et al, Oncoimmunology 7(9):e1484978 (2018)
[4] G. Isbary et al, Clinical Plasma Medicine 1 (2), 25-305 (2013)
[5] G. Collet et al, Plasma Sources Science and Technology 23 (1), 012005 (2014)
[6] T. Kisch et al, Microvascular Research, 104, 55-62 (2016)

Plenary Lecture

Low-Temperature Plasma as a Gene-Switching Technology: A New Paradigm in Plasma Bio-Science

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Low-temperature plasma (LTP) is emerging as a powerful tool in plasma bio-science, capable of regulating biological functions under ambient conditions without causing lethal damage. We propose a new framework in which LTP acts as a gene-switching technology, modulating gene expression through epigenetic mechanisms rather than genetic modification.

LTP generates reactive oxygen and nitrogen species (RONS), photons, charged particles, and transient electric fields that interact with living tissues in a highly non-equilibrium manner. These stimuli can trigger specific biochemical responses while minimizing cellular damage, making LTP a unique biophysical regulator.

Using plant seeds as a model system, we found that short LTP treatments enhance germination, early growth, and stress tolerance, including in seeds produced under heat-stress conditions. Molecular analyses revealed that these effects are associated with selective DNA demethylation of germination-related genes, such as OsABA8’OH3 and OsAmy family genes in rice, resulting in increased expression of pathways involved in abscisic acid catabolism and starch mobilization.

To clarify the role of plasma-derived species, we combined mass spectrometry and modeling to quantify RONS transferred into seeds. Direct measurements demonstrated substantial nitrate accumulation and significant increases in endogenous RONS following plasma treatment, establishing a quantitative link between plasma exposure and biological responses.

These findings suggest that LTP functions as a non-invasive and potentially scalable gene-switching technology through reversible epigenetic reprogramming. Beyond agriculture, this concept offers new opportunities for controlling cellular functions, stress responses, and developmental processes across diverse biological systems, highlighting the broad potential of plasma bio-science for sustainability and environmental resilience.

References

[1] S Tsuboyama, K Kuchitsu, N Hidaka, M Shiratani, T Okumura, K Koga, Reactive species generated by cold atmospheric plasma trigger transient elevations of intracellular calcium ion and hydrogen peroxide in plant cells, Applied Physics Express 18 (8), 086001 (2025).

[2] H Shi, N Hidaka, T Okumura, P Attri, K Koga, M Shiratani, T Kawasaki, Permeation of reactive oxygen species produced by atmospheric pressure plasma through rice seed coat, Applied Physics Express 18 (5), 056001 (2025).

[3] S Tsuboyama, T Okumura, K Watanabe, K Koga, M Shiratani, K Kuchitsu, Real-time live imaging of cytosolic hydrogen peroxide and Ca2+ of Marchantia polymorpha gemmalings reveal immediate initial responses of plant cells triggered by nonthermal …, Plant Physiology and Biochemistry 216, 109172 (2024).

Plenary Lecture

Non-Thermal Gliding Arcs in Tornado: Scaling Up for Agricultural and Food Processing Applications

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The presentation is focused on new experimental and modeling results on physics and engineering of powerful Cold Gliding Arc Discharges stabilized in the reverse vortex Tornado flow. The first part of the presentation explains physics and engineering principles of the powerful gliding arc discharges, and specifics of their organization in the regimes of significant non-equilibrium in plasma volume, as well as sustaining the cold electrode emission with mostly non-thermionic emission from the discharge cathode. Modeling results define pathways for significant scaling up of the gliding arc discharges and determine the power limits of the cold plasma regimes. Experimental demonstration of the scaling up of the powerful Cold Gliding Arc Discharges stabilized in the reverse vortex Tornado flow to the level of 40 kW is further described.

The second part of the presentation is focused on applications of the powerful cold gliding arc discharges in agriculture and food processing. A special attention is paid to the reasons of avoiding high temperature plasma regimes for the plasma applications to the agriculture and food processing. Plasma treatment of very significant volumes of water at very high flow rates above (1 L/sec) are discussed. Perspectives of the cold plasma applications in the large volume agriculture and food processing are analyzed in the conclusion.

Plenary Lecture

Unraveling Physicochemical Phenomena in Plasma–Liquid Systems

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Plasma–liquid systems have emerged as powerful platforms where electrons, photons, and reactive atoms and molecules converge to generate highly active chemical environments. Among the diverse reactive oxygen and nitrogen species (RONS) produced, hydroxyl radicals and nitrogen oxides stand out as central players, yet their short lifetimes and elusive origins have limited the practical use of plasma-treated water (PTW). Our studies provide new insights into how these radicals are generated, transported, and harnessed. Plasmas also induce an electric wind, a neutral gas flow produced by momentum transfer from charged particles to neutrals via electrohydrodynamic forces. This phenomenon significantly contributes to convective transport of radicals in gases and enhances their delivery into plasma-facing liquids. In addition, the electric wind generated by the plasma can induce liquid flow within the plasma-facing liquid itself, further promoting radical transport inside the liquid phase. Notably, such electrohydrodynamic flows are not confined to laboratory plasmas but also occur in natural environments such as Earth's ionosphere and thermosphere and the solar chromosphere, underscoring their broad physical significance.

At the chemical level, we demonstrate that plasma emission drives photolysis of long-lived precursors such as nitrite and hydrogen peroxide, substantially amplifying the production of hydroxyl radicals and nitric oxide. External ultraviolet irradiation further boosts these populations, offering a controllable strategy to tailor PTW reactivity. In parallel, by systematically separating the effects of long- and short-lived species, we show that hydrogen peroxide, ozone, and nitrite are the dominant contributors to sustained antimicrobial activity, while hydroxyl radicals and superoxide anions deliver short but intense oxidative effects.

Taken together, these advances integrate plasma emission, electric-wind-driven transport, and radical chemistry into a coherent framework. By demonstrating how light, flow, and chemical reactions reinforce one another, we establish plasma-functionalized solutions as versatile antimicrobial agents with potential applications in biomedical, environmental, and agricultural domains. More broadly, the interplay between weakly ionized plasmas and deformable liquids underscores the importance of boundary physics in creating new regimes of stability, transport, and reactivity, offering both fundamental insights and new directions for plasma-based technologies.

References

[1] S. Park, W. Choe et al., *Nature Comm.* 9, 371 (2018)

[2] S. Park, W. Choe, U. Cvelbar et al., *Nature* 592, 49 (2021)

[3] J. Pyeon, S.-C. Heo, H. Lee et al., *npj Flexible Electronics*, doi.org/10.1038/s41528-026-00582-0

[4] J.Y. Park, S. Park, W. Choe et al., *ACS Appl. Mater. Interfaces* 9, 43470 (2017)

[5] S. Park, J.Y. Park, W. Choe, *Chem. Eng. J.* 378, 122163 (2019)

[6] H. Lee, S. Park, W. Choe, et al., *Chem. Eng. J.* 458, 141425 (2023)

INVITED LECTURES

Invited Lecture

Future Prospects of plasma-activated solutions

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Low-temperature plasmas have emerged as a promising technology in biomedicine owing to their ability to generate a variety of reactive oxygen and nitrogen species (RONS). Plasma-activated solutions (PAS), including plasma-activated medium (PAM) and plasma-activated liquids (PAL), have attracted increasing attention because they enable the indirect application of plasma-derived bioactive species to living systems [1, 2].

In this talk, recent advances in the development and biomedical applications of plasma-activated solutions will be reviewed. We have developed PAM and PAL and demonstrated their potential for cancer treatment and wound healing. Furthermore, the key chemical components responsible for their biological activities have been identified [3], and the intracellular molecular mechanisms underlying PAM/PAL-induced cell death have been elucidated [4]. These findings have provided important insights into the interactions between plasma-derived reactive species and biological systems.

Beyond oncology and regenerative medicine, plasma-activated solutions are being explored for a wide range of biomedical and agricultural applications, including antimicrobial treatments, biofilm control, tissue regeneration, and plant growth regulation. Recent progress in plasma chemistry, analytical techniques, and systems biology has accelerated our understanding of the mechanisms governing these effects.

The future development of plasma-activated solutions will require standardization of preparation methods, quality control of reactive species, optimization of storage stability, and comprehensive safety evaluations. Advances in these areas are expected to facilitate clinical translation and industrial implementation. Plasma-activated solutions represent a unique platform technology that bridges plasma science, chemistry, biology, and medicine, offering new opportunities to address global healthcare challenges and contribute to the realization of next-generation precision medicine.

This work was partly supported by a Grant-in-Aid for Scientific Research (A) (No. 24H00202)from the Ministry of Education, Culture, Sports, Science and Technology of Japan, as well as the joint usage / research program of the Center for Low-temperature Plasma Science, Nagoya University, and the Plasma-bio consortium.

References

[1] H. Tanaka, S. Bekeschus, D. Yan, M. Hori, M. Keidar, M. Laroussi, Cancers, 13 (2021) 1737.

[2] H. Tanaka, K. Ishikawa, M. Mizuno, S. Toyokuni, H. Kajiyama, F. Kikkawa, H.R. Metelmann, M. Hori, Rev. Mod. Plasma Phys. , 1 (2017) 1-89.

[3] H. Tanaka, Y. Hosoi, K. Ishikawa, J. Yoshitake, T. Shibata, K. Uchida, H. Hashizume, M. Mizuno, Y. Okazaki, S. Toyokuni, K. Nakamura, H. Kajiyama, F. Kikkawa, M. Hori, Sci Rep, 11 (2021) 18488.

[4] H. Tanaka, M. Mizuno, Y. Katsumata, K. Ishikawa, H. Kondo, H. Hashizume, Y. Okazaki, S. Toyokuni, K. Nakamura, N. Yoshikawa, H. Kajiyama, F. Kikkawa, M. Hori, Sci Rep, 9 (2019) 13657.

Invited Lecture

Cold Atmospheric Plasma-Induced Epigenetic Remodeling: Integrating lncRNA Regulation and m6A RNA Methylation in Cancer Cells

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Cold atmospheric plasma (CAP) is an innovative therapeutic modality that exhibits preferential toxicity toward cancer cells through complex molecular mechanisms extending beyond conventional oxidative stress pathways. This work elucidates the critical role of epigenetic regulatory networks in mediating CAP's anticancer efficacy, highlighting how plasma exposure orchestrates multilevel epigenetic reprogramming to suppress tumor cell survival. We demonstrate that CAP treatment induces comprehensive epigenetic remodeling, encompassing global reorganization of DNA methylation, dynamic redistribution of histone marks, and disruption of non-coding RNA regulatory circuits. Our findings reveal distinct epigenetic vulnerability profiles across cancer subtypes, with estrogen receptor status significantly influencing cellular responses in breast cancer models. Notably, CAP exposure triggers widespread CpG methylation alterations, reduces activating H3K4me3 marks at oncogenic loci, and suppresses tumorigenic microRNAs—including miR-19a-3p—via promoter hypermethylation. Furthermore, we identify novel regulatory axes involving the long non-coding RNA IRF1-AS1, which functions as a molecular sponge in CAP-treated cells, as well as HIF1A–ARNT transcriptional networks that coordinate downstream epigenetic cascades.

We also performed a transcriptome-wide analysis of m6A RNA modification in breast cancer cells following CAP treatment. ATP5MK, which encodes a subunit of mitochondrial ATP synthase, showed increased m6A levels and a corresponding decrease in expression upon CAP treatment. The regulatory mechanism and functional consequences of this m6A modification are currently under investigation.

These mechanistic insights into CAP-driven epigenetic reprogramming not only advance our understanding of plasma medicine but also establish a foundation for optimizing personalized CAP protocols based on tumor-specific epigenetic landscapes.

This work was supported by the Basic Science Research Program (NRF-2022R1A2C1003483) of the National Research Foundation of Korea, funded by the Ministry of Education, Science and Technology.

References

[1] S. Lee et al., *Scientific Reports*, 6, 3005 (2016).
[2] S. Choi et al., *Scientific Reports*, 15, 37259 (2025).
[3] H.W. Ji et al., *Cancers,* 12, 2640 (2020).

Invited Lecture

Plasma-Functionalized Liquids For Tissue Decontamination

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The use of antibiotics remains standard during tissue processing and cell isolation workflows, although it conflicts with efforts to reduce antimicrobial resistance. In this context plasma-functionalized liquids emerged as an interesting option [1]. In particular, the chemicals formed during plasma exposure have the potential for high antimicrobial activity [2,3]. Herein, we present plasma-based strategies for the decontamination of umbilical cord tissue as a potential antibiotic-free alternative for stem cell isolation and subsequent cell-based applications. Plasma functionalized liquids (PFLs) were generated using different plasma sources, including microwave discharge, dielectric barrier discharge, and spark-based systems, and subsequently applied to tissue samples under controlled conditions. The resulting liquids were physicochemically characterized and evaluated for antimicrobial performance and tissue compatibility. The tested PFLs varied regarding their chemical composition and pH values, which effected the downstream impact. Across the tested systems, PFL treatment enabled substantial bacterial reduction, with log reductions ranging from 3.65 to 7.41 depending on the plasma source and protocol applied. Importantly, viable cells could be isolated from treated tissues under completely antibiotic-free conditions. Further improvement of the workflows achieved cell yields up to 5.45 × 10^5 cells/g with viability values of 84.24%, demonstrating that effective decontamination can be combined with preservation of cell functionality. The best performance was achieved by microwave-generated PFLs. In contrast, direct or insufficiently optimized spark-discharge approaches showed incomplete antimicrobial efficacy or limited tissue tolerability, highlighting the importance of selecting appropriate plasma generation and application modes.

These findings demonstrate that plasma-functionalized liquids offer a versatile, non-chemical, residue-free approach for tissue decontamination. The method supports sustainable cell processing and may provide a scalable platform for applications in medical settings as well as in food and agricultural industry.

This work was supported by the Federal Ministry of Research, Technology and Space (grant 031B1259C).

References

[1] R. Laurita, D. Barbieri, M. Gherardi, V. Colombo & P. Lukes, *Clinical Plasma Medicine* **3**, 53–61, Chemical analysis of reactive species and antimicrobial activity of water treated by nanosecond pulsed DBD air plasma (2015).

[2] W. Chiappim, *et al., Water* **13**, Antimicrobial Effect of Plasma-Activated Tap Water on Staphylococcus aureus, Escherichia coli, and Candida albicans. (2021).

[3] O. Handorf, H. Below, U. Schnabel, K. Riedel & J. Ehlbeck, *Journal of Physics D: Applied Physics* **53** , Investigation of the chemical composition of plasma-treated water by MidiPLexc and its antimicrobial effect onL. monocytogenesandPseudomonas fluorescensmonospecies suspension cultures. (2020).

Invited Lecture

Enhanced Inactivation of Multispecies Biofilms Using Plasma-Activated Nanobubble Water Combined with UV-C and Hydrogen Peroxide

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Plasma-activated water (PAW) is a promising antimicrobial agent due to the presence of reactive oxygen and nitrogen species (RONS), elevated oxidation-reduction potential (ORP), and acidic pH. Its antimicrobial activity, however, can decline with increasing treatment volumes as RONS concentrations decrease. Incorporating nanobubbles produces Plasma-Activated Nanobubble Water (PNB-W), with enhanced RONS concentrations. The addition of hydrogen peroxide and Ultraviolet-C (UV-C) treatment can further improve the antimicrobial efficacy of PNB-W [1]. This study aimed to evaluate the biofilm inactivation efficacy of PNB-W and the enhanced efficacy after the addition of hydrogen peroxide and UV-C treatment against multispecies biofilms.

An 8 L batch reactor was used to generate PNB-W over 20 minutes. The process integrated simultaneous plasma generation, UV-C treatment, and the addition of 340 ppm H_2O_2 for advanced oxidation processes. Multispecies biofilms of *Pseudomonas*, *Salmonella*, and *Aeromonas* species were grown on stainless steel (SS 304) coupons (25 × 25 mm) to simulate a food contact surface. To characterize the physicochemical properties of the solutions, Optical Emission Spectroscopy (OES) was used to identify gas-phase species, while colorimetric kits were used to estimate the dissolved RONS in the water. Nanobubble characteristics were analyzed via Nanoparticle Tracking Analysis (NTA) and Zeta Potential measurements.

NTA characterization revealed that plasma exposure significantly refined bubble morphology, decreasing the average diameter to 134 ± 4 nm. The zeta potential increased to -42.2 ± 1.5 mV, indicating the formation of a highly stable system, resistant to bubble coalescence. The PNB-W treatment demonstrated substantial antibiofilm activity, which was synergistically enhanced by the combination of UV-C and H_2O_2. This integrated approach achieved a reduction of >5 log CFU/cm^2 in the multispecies biofilm population after a 10 minutes treatment. Further analysis showed elevated ORP, electrical conductivity, and RONS concentrations in the combined treatments, correlating directly with the enhanced biofilm inactivation rates. This study highlights the potential of PNB-W technology as a novel and efficient method for biofilm control and food safety applications.

Acknowledgement:

The authors would like to thank Results Driven Agriculture Research (RDAR) and Natural Sciences and Engineering Research Council (NSERC) of Canada.

References

[1] B. Tiwari, S. Dinesh, V. Prithiviraj, X. Yang, and M. S. Roopesh, Journal of Water Process Engineering, 69, 106676 (2025).

Invited Lecture

An ETOP-Based Unified Plasma Dose Framework Incorporating Chemical, Electrical, and Photonic Effects

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Although atmospheric-pressure non-thermal plasma (APNP) has demonstrated tremendous potential in biomedical applications, the lack of a standardized plasma dose definition remains one of the major obstacles limiting reproducibility, parameter transferability, and clinical translation. To address this challenge, we first introduce the concept of Equivalent Total Oxidation Potential (ETOP) as a physically meaningful definition of plasma dose [1]. The ETOP framework is based on the dominant role of reactive oxygen and nitrogen species (RONS) in plasma-induced biological effects and incorporates three components: the oxidative contribution of RONS, the effects of non-RONS physical agents such as UV/VUV radiation and electric fields, and the synergistic interactions among these factors. Using bacterial reduction factor (BRF) as an indicator of plasma biological effect, we demonstrate that ETOP can establish a quantitative dose-response relationship capable of comparing different plasma operating conditions. Building upon this framework, the talk further presents a machine learning-assisted ETOP prediction method designed to overcome the practical difficulty of measuring numerous plasma-generated reactive species under varying operating conditions. By combining laser-induced fluorescence diagnostics with artificial neural network (ANN) modeling, the proposed approach enables rapid and accurate prediction of ETOP values directly from plasma electrical parameters [2]. This method significantly improves the feasibility of plasma dose quantification and provides a practical route toward standardized plasma dose evaluation in biomedical applications. To achieve stable and controllable plasma dose delivery under dynamically changing environments, we further introduce a real-time plasma dose intensity control strategy based on deep reinforcement learning (DRL) [3]. Finally, this talk discusses our latest extension of the ETOP framework toward a unified dose definition that integrates chemical, electrical, and photonic effects. Explicit equivalent dose definitions are established for electric fields and UV irradiation, and different physical energy channels are quantitatively mapped onto a common ETOP scale through experimentally determined weighting coefficients [4]. Reanalysis of multiple plasma inactivation datasets reveals that apparently scattered experimental results collapse onto unified sigmoidal dose-response curves when expressed using the proposed equivalent dose framework. These

findings demonstrate the feasibility of constructing a physically grounded and experimentally accessible universal plasma dose metric. Overall, this work aims to advance plasma medicine from empirical parameter optimization toward a quantitative, controllable, and standardized dosimetry science. The proposed ETOP-based framework provides a foundation for cross-platform comparison, intelligent plasma dose control, and future clinical translation of plasma technologies.

References

[1] H. Cheng, J. Xu, X. Li, D. Liu and X. Lu, *Phys. Plasmas*, 27, 063514 (2020).
[2] E. Wu, K. Song, X. Pei, L. Nie, D. Liu, and X. Lu, *Appl. Phys. Lett*, 125, 203703 (2024).
[3] E. Wu, K. Song, X. Pei, L. Nie, A. Mesbah, and X. Lu, *Appl. Phys. Lett*, 127, 053701 (2025).
[4] E. Wu, J. Liu, Z. Li, D. Liu, L. Nie, and X. Lu, *High Voltage*, (2026).

Invited Lecture

Engineering a Scalable Plasma-Activated Water System with Tunable Reactive Species for Nitrogen Fixation and Sustainable Agricultural Applications

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Plasma-activated water (PAW) has attracted considerable attention for sustainable agriculture due to its ability to generate reactive oxygen and nitrogen species (RONS) beneficial for plant growth, microbial control, and nitrogen supplementation [1-3]. In this work, we report the engineering development of a scalable Plasma-Activated Water (PAW) platform with tunable reactive species for plasma-assisted nitrogen fixation and environmentally friendly agricultural applications. The developed BI-PAW™ system employs a Venturi-microbubble assisted cold atmospheric plasma configuration to enhance plasma discharge stability, plasma–liquid interaction, and efficient transfer of reactive species from the gas phase into water.

A key feature of the system is the controllable gas feeding configuration, allowing selective generation of RONS by adjusting the composition and relative flow rates of air, nitrogen, oxygen, and water vapor introduced into the plasma region. By tuning the gas-to-moisture ratio, the system can selectively produce ROS-dominant or RNS-dominant PAW containing hydrogen peroxide (H_2O_2), nitrate, nitrite , and ammonia-related species suitable for plasma-assisted liquid fertilizer applications. Air-water vapor operation significantly enhances nitrate production through plasma nitrogen fixation, while nitrogen-water vapor operation promotes controllable ammonia formation and alternative nitrogen reaction pathways. The Venturi microbubble system further improves gas dissolution and mass transfer of RONS into water, leading to enhanced chemical yield and stable continuous operation.

The prototype currently operates at an input power of approximately 1 kW and can continuously produce up to 20 L of PAW per hour with stable temperature control. The modular stainless-steel architecture enables straightforward scale-up and long-term 24/7 operation for field deployment. The developed system demonstrates strong potential as a sustainable platform for decentralized green fertilizer production, plasma-assisted crop cultivation, and next-generation plasma agriculture.

References

[1] V. Rathore and S. K. Nema, Plasma Chem Plasma Process, 45, 1103-1123(2025)
[2] N. Ali and Y. Dong, Front. Plant. Sci., 17, 1754073(2026).
[3] N. V. D. Long and et.al., Chemical Engineering Journal, 528, (2026).

Invited Lecture

The Dawn of Quantum Therapy and Bio-Therapeutic Applications of Infrared Pearlite Boards

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As modern medicine undergoes a paradigm shift from conventional structural interventions toward energy- and quantum-based biological modeling, electromagnetic wave therapy has emerged as a crucial therapeutic domain. Historically established by Niels Finsen (1903 Nobel Laureate in Physiology or Medicine) through the discovery of light therapy for *Lupus vulgaris*, phototherapy demonstrates that light, heat, and electromagnetic frequencies actively regulate physiological processes.

This paper investigates the biological mechanisms and therapeutic utility of the high-emissivity **Pearlite Quantum Board**, an inorganic porous volcanic ceramic composite designed for near-infrared (NIR) and far-infrared (FIR) radiation emission.

The IR radiation effect the cells and blood vessels, treating many diseases such an tumor shrinkge and chronic inflammation. We list some main effects of this IR radiation:

Mitochondrial Activation: Photons in the NIR spectrum are absorbed by chromophores (such as cytochrome c oxidase) within mitochondria, triggering ATP synthesis, controlled ROS signaling, and the liberation of Nitric Oxide (NO).

Vascular & Anti-Inflammatory Effects: Diffused NO induces long-term microvascular vasodilation, improving regional microcirculation, activating key transcription factors (NF-kB, AP-1), and reducing systemic inflammation.

FIR Non-Thermal Effects:FIR activates body water molecules, increases blood oxygen content, decreases blood acidity, and enhances metabolic waste clearance.

In summary, therapeutic quantum heating room systems incorporating Pearlite Quantum Boards, provide non-invasive targeted hyperthermia for abdominal, pelvic, and deep-tissue pathologies, presenting a scalable approach for pain management, localized sterilization, tumor shrinkage, and chronic inflammation control.

Keywords: *Quantum Therapy, Far-Infrared (FIR), Near-Infrared (NIR), Pearlite Quantum Board, Photobiomodulation, Nitric Oxide, Hyperthermia, Cancer Therapeutics*

Invited Lecture

Low Temperature Plasma-Assisted Synthesis of HCN and CO from C, N_2, and H_2O for Sustainable Oxamide Fertilizer Production

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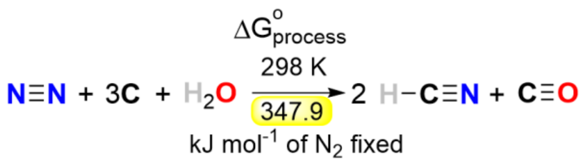
Abstract: Hydrogen cyanide (HCN), the key precursor to oxamide [], is of interest as oxamide is a more efficient slow-release fertilizer than urea [1]. Presently, HCN is produced from Haber–Bosch produced through its Blausäure-Methan-Ammoniak (BMA) coupling with CH_4. This two-step process is energetically and economically unattractive for large-scale oxamide fertilizer production. Here, we present an alternative: At 1 atm and 40 °C, sustainable carbon feedstocks, including charcoal, graphite powder, milled carbon fibers, and coal fly ash, react with to generate HCN and CO through plasma-induced activation involving diradicals [1]. Oxygen in the CO product is ultimately derived from water. A mechanistic sequence is proposed for this process. No measurable carbon conversion occurs without plasma activation and aluminum xerogel additives, (prepared by hydrolysis of aluminum *sec*-butoxide in the presence of methanol-soluble transition metal salts), significantly enhance the plasma reaction. Fe(II)-modified xerogels gave the best performance, achieving 5900–6019 ppm HCN (≈0.6 vol%) and 39032–63200 ppm CO (≈5 vol%). Notably, these lab results were obtained at dissipated energies within a factor of 20 of current commercial HB–BMA HCN production plants, highlighting the promise of this route as a sustainable alternative.



Keywords:
Hydrogen cyanide; Oxamide; Low temperature plasma; Nitrogen fixation; Carbon monoxide

Fig. 1. *Low-temperature plasma assisted reaction pathways for HCN and CO co-production and related N_2 fixation processes.*

Acknowledgement: We thank the University of Nottingham and the Lubrizol Prosperity Partnership (EPSRC: EP/V037943/1) and the Metal Atoms on Surfaces and Interfaces (MASI) for Sustainable Future programme grant (EP/V000055/1) for facilitating this research. This study was supported by Engineering and

Physical Sciences Research Council (Grant EP/V037943/1, EP/Y035402/1 and EP/V000055/1).

Reference

[1] M. Molteni,‡ T. R. Acharya,‡ B. Mulholland-Prescott, T. Clayton, D. Kays, P. Licence, M. Sutton, G. Walker, E. Slikboer, S. Otieno, A. Weilhard, E. Kohlrausch, D. Robinson, J. Wright, S. Woodward. “Plasma Conversion of C, N_2 and H_2O into HCN and CO at Atmospheric Pressure and Near Ambient Temperature: Towards Oxamide Fertilizers?” *ChemistryEurope* **2026**, *4*, e202500320 (doi link) [‡ These authors share first author status].

Invited Lecture

Comparative Investigation of DC and Microwave Plasma Systems for Bacterial Inactivation: Spectroscopic and Microscopic Analysis

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Non-thermal plasma has been shown to be a promising antimicrobial technology for biomedical infection control and sterilization [1]. A comparative study is performed in this work for a sub-atmospheric direct current (DC) plasma system and 2.45 GHz microwave (MW) plasma system on gram-positive *Staphylococcus aureus* and gram-negative *Salmonella abony*. The outstanding bacterial reduction was attributed to the production of reactive oxygen species (ROS) which created oxidative stress in both plasma systems. The MW plasma showed fast antimicrobial effect, achieving complete 6-log reduction in 300 s for both *S. aureus* and *S. abony*, while the DC plasma achieved the same level of reduction in 60 min. The solution was performed by spectrofluorometric methods, which showed increased production of $^{\bullet}OH$ and H_2O_2 in plasma treated bacterial suspensions causing membrane depolarization and oxidative damage. The UV–Visible spectroscopy results confirmed the degradation of DNA via hyperchromic effects at 260 nm, and the ATR-FTIR and Circular Dichroism studies suggested leakage of biomolecules in the cells and changes in secondary protein structure. The morphological deformation and the disruption of the cell membrane was confirmed by FE-SEM and the exposure to plasma led to increased bacterial cell death, which was confirmed by confocal microscopy and flow cytometry [2,3]. Comparative results offer insights into the mechanism of plasma induced bacterial inactivation and the possible application of the DC and MW plasma systems for advanced sterilization and biomedical applications.

Acknowledgement: The authors are thankful to School of Life Sciences, Central University of Gujarat, Gandhinagar, India for providing the required lab and instrumentation facilities for post plasma treatment experiments. Authors also thankful to central Instrumentation facility at Indian Institute of Technology, Gandhinagar for availing imaging facilities.

References

[1] Sakudo, A., Yagyu, Y., & Onodera, T, *International journal of molecular sciences*, 20(20), 5216 (2019).

[2] Barkhade, T., Nigam, K., Ravi, G., Nema, SK., Rawat, S, *Scientific Reports*, 15, 18052 (2025).

[3] Barkhade, T., Nigam, K., Ravi, G., Nema, SK., Rawat, S, *Plasma Chemistry and Plasma Processing*, 44, 429–454 (2024).

Invited Lecture

Antibacterial Efficacy of Plasma-Activated Water Against Enterococcus faecalis Biofilms: An In Vitro and Ex Vivo Study

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Persistent root canal infections are primarily associated with biofilm-forming microorganisms, particularly *Enterococcus faecalis* [2,3,5]. Although sodium hypochlorite remains the gold-standard irrigant, concerns regarding cytotoxicity have prompted the search for safer alternatives. Plasma-activated water (PAW), enriched with reactive oxygen and nitrogen species, has emerged as a promising antimicrobial solution [1,4]. In this study, PAW was generated by activating deionized water with a non-thermal plasma device for 2–12 min. In the in vitro model, 48-hour E. faecalis biofilms were exposed to PAW and antibacterial efficacy was evaluated by colony-forming unit (CFU) counting. In the ex vivo model, thirty extracted single-rooted teeth infected with E. faecalis for seven days were irrigated with deionized water, 2.5% sodium hypochlorite, or PAW. Remaining bacterial viability was quantified by CFU analysis and biofilm morphology was examined using scanning electron microscopy. PAW demonstrated activation time- and contact time-dependent antibacterial activity. Twelve-minute activated PAW completely eliminated bacteria after 6 h in vitro. In the ex vivo model, PAW significantly reduced bacterial counts compared with deionized water and exhibited antimicrobial efficacy comparable to 2.5% sodium hypochlorite. Scanning electron microscopy confirmed substantial disruption and removal of biofilm structures following PAW irrigation. These findings demonstrate that PAW possesses significant antibacterial activity against E. faecalis biofilms and may serve as a promising adjunctive root canal irrigant. Further investigations are warranted to optimize treatment protocols and evaluate clinical applicability.

Acknowledgement

This research was funded by an intramural endowment fund from the Faculty of Dentistry, Chiang Mai University, Thailand.

References

[1] R. Zhou, R. Zhou, P. Wang, Y. Xian, A. Mai-Prochnow, X. Lu, et al., *J. Phys. D: Appl. Phys.*, 53, 303001 (2020).

[2] Y. Li, K. Sun, G. Ye, Liang Y, H. Pan, G. Wang, et al., *J. Endod.*, 41, 1325–1330 (2015).

[3] J. Pan, K. Sun, Y. Liang, P. Sun, X. Yang, J. Wang, et al., *J. Endod.*, 39, 105–110 (2013).

[4] Q. Wang and D. Salvi, *LWT*, 149, 111847 (2021).

[5] P.N. Nair, *Periodontol*. 2000, 13, 121–148 (1997).

Invited Lecture

Engineering Plasma-Activated Hydrogel Conditions for Enhanced Inactivation of Pseudomonas aeruginosa

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Pseudomonas aeruginosa is a clinically important opportunistic pathogen commonly associated with infected, moisture-rich wounds and biofilm formation, posing a major challenge to conventional antimicrobial therapies. Building on plasma-activated hydrogel (PAH) systems that integrate plasma-activated water (PAW) into a hydrogel matrix to enhance reactive oxygen and nitrogen species (RONS) stability and contact with biological surfaces, this study proposes a PAH-based screening platform to evaluate antimicrobial performance against *P. aeruginosa* under systematically varied formulation and processing conditions. The experimental concept employs a fixed gel ratio of 3:5 and a PAW generation time of 20 minutes, previously identified as a promising baseline for RONS retention and antibacterial activity, and focuses on comparing multiple PAH formulations that differ in their liquid phase treatment and gel composition while maintaining clinically relevant handling properties. A two-level Taguchi design is planned to screen the main effects of selected factors, such as PAW pretreatment mode and gel formulation type, on bacterial inactivation, using log CFU/mL and log reduction as primary response variables after exposure of *P. aeruginosa* to each hydrogel condition. This structured design-of-experiments approach aims to rapidly identify influential PAH formulation parameters and operating windows that yield enhanced antimicrobial potential, thereby providing a data-driven basis for subsequent confirmatory studies on biofilm disruption, chronic wound models, and translational wound-dressing development.

Invited Lecture

$ZnFe_2O_4$-Catalyzed Dielectric Barrier Discharge Plasma for Sustainable Degradation of Sulfathiazole in Aqueous phase

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MEDBD assisted by $ZnFe_2O_4$ was employed to enhance the performance of plasma on the degradation using STZ as the model pollutant. STZ was chosen due to its widespread occurrence and potential risks to human health, aquatic life and hence the environment. Firstly, $ZnFe_2O_4$ in the laboratory was synthesized via chemical co-precipitation method and was characterized to gain deeper understanding of the properties of catalyst. The degradation efficiency seems to have significantly increased after the addition of $ZnFe_2O_4$ because of the enhancement of ROS, specifically hydroxyl radical (•OH) and H_2O_2. After the optimization of several parameters, 98.4% of degradation and 3.7 g kW^{-1} $h^{-1}$of E.Y were obtained with the optimal conditions being: 500 mL volume, 10.0 mg L^{-1} STZ concentration, 1.0 g L^{-1} $ZnFe_2O_4$ concentration, neutral pH, and 40 min of treatment time. LC-MS experiment helped in determining the degradation pathways and major reactive species involved in the degradation. Furthermore, scavenger test also proved that O_3 and •OH both played major role in the degradation of STZ. $ZnFe_2O_4$ is a heterogenous catalyst with only 7% metal leaching proving its reusability. In addition, this study not only observed degradation efficiency but also examined the toxicity after degradation on cells (HEK-293) and plant (mung beans) further proving the efficiency of this method. At last, this research highlights the strong synergistic interaction between plasma and $ZnFe_2O_4$ demonstrating this system as an innovative solution for the removal of pollutants from the environment.

Invited Lecture

Effects of Cold Atmospheric Plasma in Head and Neck Squamous Cell Carcinoma Ex Vivo

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Introduction Head and neck squamous cell carcinoma (HNSCC) remains a major global health challenge, particularly in low and middle-income countries, where disease burden and mortality are disproportionately high. Despite advances in chemotherapy and radiotherapy, treatment efficacy is often limited by toxicity, drug resistance, and tumor recurrence. Cold Atmospheric Plasma (CAP), a non-thermal ionized gas rich in reactive oxygen and nitrogen species (RONS), has emerged as a promising anti-cancer modality capable of selectively targeting tumor cells through redox-dependent mechanisms. However, the molecular effects of CAP in clinically relevant patient-derived HNSCC models remain poorly understood. This study attempts to understand the metabolic changes in patient derived tumor explants following CAP exposure.

Methods Fresh HNSCC specimens obtained from patients were established as ex vivo tumor explants using a gelatin sponge-based culture system supplemented with DMEM and antibiotics. Explants were exposed to helium CAP for 60 s or 120 s at 16-17 kV, with pulse width modulation frequency of 70% with a flow rate of 4 slm using a custom-built plasma device. Gene expression analysis of prognostic and metabolic markers, including MCT4, XPR1, GLUT3, and MFT, was performed using quantitative PCR. CAP-induced changes in oxidative stress-associated pathways and amino acid transporters were evaluated, while tumor proliferative activity was assessed by Ki67 immunohistochemistry.

Results CAP exposure significantly modulated redox-regulatory pathways within HNSCC explants, including altered expression of the antioxidant enzyme catalase. CAP also induced differential regulation of L-type amino acid transporters, suggesting disruption of tumor metabolic adaptations. These molecular alterations were associated with enhanced intracellular drug accumulation, indicating improved membrane permeability and transporter-mediated uptake. While 60 s CAP exposure produced limited effects on cellular proliferation, 120 s exposure resulted in a marked reduction in Ki67-positive cells, demonstrating a dose-dependent anti-proliferative response. Collectively, these findings indicate that CAP reprograms both redox homeostasis and metabolic activity in patient-derived HNSCC tissues.

Conclusion This study provides mechanistic evidence that CAP modulates oxidative stress signalling and transporter function in clinically relevant HNSCC explants, resulting in enhanced drug uptake and reduced tumor proliferation. Our findings support the development of CAP as a non-invasive adjuvant strategy to improve therapeutic responsiveness in HNSCC and highlight the value of patient-derived explant models for translational plasma oncology research.

Acknowledgement: This work is supported by Department of Science and Technology (DST) Ref No. DST/INSPIRE Fellowship/2024/IF230496.

Invited Lecture

Plasma application to soil and hydroponic culture

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Remediation of pollutant-contaminated soil and enhancement of soil fertility is one of area that active research is conducted these days [1,2]. We have evaluated the potentiality of gas generated using atmospheric-pressure non-thermal plasma or plasma treated water in remediation of soil contaminated with organic waste or total petroleum hydrocarbons (TPH) and enhancement of soil fertility. Microbial load in field soil contaminated with organic waste was decreased (approximately 10–29% of aerobic natural microbiota) after 60 min of treatment with gas generated using four pairs of cylinder-type DBD electrode plasma [3]. The plasma treatment resulted in a slight decrease in soil microbial diversity. Plant growth and nitrate level increased significantly in plasma-gas-treated field soil. Plasma treated tap water enhanced TPH degradation efficiency by 8% compared to control. Addition of frass soil increased removal efficiency by 29% compared to control. Bok-choy plants cultured in 1× Hoagland solution (nutrient) treated with plasma generated gas and harvested on the 35th day showed the increase in length of shoot and root and dry biomass. Our data demonstrates the possibility that plasma-generated gases and plasma-treated water can reduce contamination with improvement of plant growth in soil and enhance the growth of plants in hydroponic culture. This work was supported by the National Research Foundation of Korea (NRF) (RS-2021-NR060112, 2020R1F1A1070942) and partly by Korea Agriculture Technology Promotion Agency.

References:

1) J. Schierstaedt, R. Grosch, A. Schikora, FEMS Microbiol. Lett., 366, fnaa016 (2020).
2) J. Suman, A. Rakshit, S.D. Ogireddy, S. Singh, C. Gupta, J. Chandrakala, Front. Soil Sci., 2, 821589 (2022).
3) W. Ketya, N.-N. Yu, T.R. Acharya, E.-H. Choi, J. Hazard. Mat., 483, 136643 (2025).

Invited Lecture

Plasma-Generated Nitric Oxide Water for Pathogen Control and Skin Cosmetics

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This presentation highlights the scientific foundations and translational potential of non-thermal plasma technologies for diverse applications in pathogen control, environmental remediation, agriculture, nanobiotechnology, and biomedicine. As the global demand for sustainable and effective technologies continues to grow, our research focuses on the development of eco-friendly plasma-based strategies capable of addressing challenges associated with microbial contamination, emerging infectious diseases, and environmental pollutants. Particular emphasis is placed on scalable plasma platforms designed for the inactivation of pathogenic microorganisms present in water, air, soil, and biological environments.

Our laboratory conducts both fundamental and applied research on plasma-generated nitric oxide (NO)-enriched water and other plasma-activated liquids as versatile bioactive platforms. These technologies have demonstrated broad applicability in viral and bacterial inactivation, wound healing, immune modulation, cancer therapy, agricultural enhancement, and the green synthesis of functional bio-nanomaterials. By harnessing plasma-derived reactive oxygen and nitrogen species (RONS), these systems provide a chemical-free and environmentally responsible approach for biological and environmental interventions. Recent studies have further revealed the potential of plasma-generated NO water in anti-aging and cosmetic applications, as well as its ability to modulate cellular signaling pathways associated with tissue regeneration and cancer suppression.

In addition, we will present recent advances in plasma-based pathogen control strategies, including the development of nitric oxide-enriched plasma-activated water, hydrogels, nanoemulsions, and other plasma-enabled delivery platforms. These technologies offer effective, sustainable, and cost-efficient solutions for controlling bacteria, viruses, and other harmful microorganisms while maintaining high levels of biocompatibility and environmental safety. Their adaptability also supports applications in precision agriculture, food safety, biomedical engineering, and future space biology research.

Overall, environmentally benign plasma technologies represent a rapidly emerging frontier with significant potential to transform healthcare, agriculture, environmental science, and nanotechnology. By integrating advances in plasma physics, chemistry, materials science, and biology, these innovative platforms are paving the way toward next-generation solutions for cancer therapy, infectious disease control, wound healing, immune activation, sustainable agriculture, and advanced bio-nanotechnological products.

Invited Lecture

Comparative Evaluation of Plasma Feed Gases on Antimicrobial activity and wound healing responses in Diabetic Foot Ulcer

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Abstract:

Diabetic foot ulcers (DFUs) are chronic non-healing wounds that are complicated with multidrug-resistant pathogens and impaired tissue repair. Cold atmospheric plasma (CAP) has emerged as a promising therapeutic strategy. However, the influence of plasma feed gases on antimicrobial efficacy and regenerative responses remains unclear. This study comparatively evaluated argon- and helium-based CAP systems in DFU-associated infections by integrating plasma chemistry, antimicrobial activity, genotoxic safety and wound healing responses.

Plasma discharge characteristics and reactive oxygen and nitrogen species (RONS) were assessed using oscilloscope measurements, Amplex Red and Griess assay respectively. Antimicrobial activity was evaluated by quantifying the bacterial zone of inhibition in ten clinical DFU isolates. Bacterial cell viability and biofilm disruption were examined using DFU gram-positive and gram-negative bacterial isolates. ESKAPE pathogens were further investigated using STRING protein–protein interaction and ShinyGO pathway enrichment analyses. Genotoxic safety was assessed in peripheral blood mononuclear cells (PBMCs) using Lumit assay for γ-H2AX followed by gene expression analysis of inflammatory and wound-healing markers.

Both CAP systems generated stable discharges but exhibited distinct RONS profiles. Argon CAP produced substantially higher hydrogen peroxide levels (88.66 ±1.55μM) whereas helium CAP generated higher nitrite concentrations (89.49 ±1.21 μM). Argon feed gas exhibited superior antimicrobial efficacy, achieving up to 76.75 ±12.30 % and 67.3 ±2.35% of inhibition in Gram-positive and Gram-negative isolates respectively following P120s exposure. Increased zone of inhibition was observed while using argon CAP against representative ESKAPE pathogens such as *Staphylococcus aureus* (70.27%), *Klebsiella*

pneumoniae (50.28%) and *Pseudomonas aeruginosa* (50.27%). CAP exposure also markedly disrupted the formation of biofilm. Network and pathway analyses identified oxidative stress responses, biofilm formation and bacterial stress response pathways as key targets. Importantly, CAP exposure does not induce any significant DNA damage in PBMCs and promoted pro-regenerative profile characterized by the increase of IL-10 and TGF-β expression.

Argon-based CAP demonstrated superior antimicrobial and anti-biofilm efficacy while maintaining reduced genotoxicity and enhancing pro-regenerative profiles. These findings highlight the translational potential of CAP as a multifunctional adjunctive therapy for DFU and emphasize plasma gas selection in optimizing therapeutic outcomes. This is the first pre-clinical study in DFU integrating plasma characterization, antimicrobial efficacy, ESKAPE pathogen network biology, host-cell safety, and regenerative molecular responses within a comparative argon–helium CAP framework.

Acknowledgement: This study is funded by Indian Council of Medical Research Grant No: IIRPSG 2024-01- 00024 and University Grants Commission's National Fellowship for Other Backward Categories –Senior Research Fellowship, 202223-221610177189.

References:

Murali R, Singh P, Ragunathan D, Gandhirajan RK, et al. Antimicrobial Activity of Cold Atmospheric Plasma on Bacterial Strains Derived from Patients with Diabetic Foot Ulcers. J Microbiol Biotechnol. 2024;34(11):1-9.2

Roopak Murali RE, Joanna Pauline Samuel, Pooja Singh, Shivangi Saha, Maneesh Singhal and Rajesh Kumar Gandhirajan. Cold Atmospheric Plasma (CAP) in Wound Healing: Harnessing A Dual Edged Sword. Redox Experimental Medicine. 2023;1(1)

Invited Lecture

Nonthermal Plasma-Driven Skin Rejuvenation with Nitric Oxide Water

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The field of biotherapeutics is increasingly focused on plasma-based interventions, particularly nonthermal plasma (NTP) and its derivative, plasma-generated nitric oxide–enriched water (NOW). This study explores the potential of NOW as a noninvasive strategy for cellular rejuvenation and modulation of aging-associated signaling pathways. Nonthermal plasma generates reactive oxygen and nitrogen species (RONS) that regulate key molecular processes linked to cellular homeostasis and age-related functional decline. Nitric oxide (NO), a central reactive nitrogen species, plays a critical role in diverse physiological processes, and its endogenous levels decline with age, contributing to increased susceptibility to skin-related disorders. Leveraging plasma-generated NO, we investigate NOW as a bioactive agent in human dermal fibroblasts, with a focus on gene expression profiles associated with extracellular matrix (ECM) remodeling and cellular senescence. Collectively, this work provides a framework for understanding how plasma-derived NO-based interventions may influence cellular regulatory networks relevant to regenerative and anti-aging applications in dermatological and cosmetic biotherapeutics.

This study was supported by the National Research Foundation (NRF) of Korea, funded by the Korean government (RS-2021-NR060112 and RS-2025-16071518).

References

Luo, J. D., & Chen, A. F. (2005). Nitric oxide: a newly discovered function on wound healing. Acta Pharmacologica Sinica, 26(3), 259-264.

Hsu, Y. C., Hsiao, M., Wang, L. F., Chien, Y. W., & Lee, W. R. (2006). Nitric oxide produced by iNOS is associated with collagen synthesis in keloid scar formation. Nitric Oxide, 14(4), 327-334.

Kim, J. H., & Choi, M. S. (2023). Nitric oxide signal transduction and its role in skin sensitization. Biomolecules & Therapeutics, 31(4), 388.

Schnellmann, R., & Gerecht, S. (2023). Reconstructing the ageing extracellular matrix. Nature Reviews Bioengineering, 1(7), 458-459.

Xu, P., Wang, M., Song, W. M., Wang, Q., Yuan, G. C., Sudmant, P. H., ... & Zhang, B. (2022). The landscape of human tissue and cell type specific expression and co-regulation of senescence genes. Molecular neurodegeneration, 17(1), 5.

Jaiswal, A., Kaushik, N., Acharya, T. R., Uhm, H. S., Choi, E. H., & Kaushik, N. K. (2024). Antiaging in a Bottle: Bioactive Competency of Plasma-Generated Nitric Oxide Water for Modulation of Aging-Related Signature in Human Dermal Cells. ACS Applied Materials & Interfaces, 16(44), 59991-60007.

N.K. Kaushik, P. Bhartiya, N. Kaushik, Y. Shin, L.N. Nguyen, J.S. Park, D. Kim, E.H. Choi, Nitric-oxide enriched plasma-activated water inactivates 229E coronavirus and alters antiviral response genes in human lung host cells, Bioact. Mater. 19 (2023) 569–580. https://doi.org/10.1016/J.BIOACTMAT.2022.05.005.

Invited Lecture

UV-vis Spectrophotometry for Measuring Plasma-induced Reactive Oxygen and Nitrogen Species

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An atmospheric-pressure helium microplasma jet is one of the most efficient plasma sources for generating and delivering highly reactive oxygen and nitrogen species (RONS). In the main discharge and downstream regions, various positively and negatively charged species, as well as neutral reactive oxygen species (ROS) and reactive nitrogen species (RNS), are present. Interestingly, hydroxyl radicals (•OH), superoxide anion radicals (O_2^-•), and nitric oxide radicals (•NO), such highly reactive species, could be delivered further downstream of the plasma jet, enveloped in laminar gas flow [1,2]. In our previous studies, we measured the concentrations of RONS, hydrogen peroxide (H_2O_2), nitrite (NO_2^-), nitrate (NO_3^-), and dissolved oxygen in water [3-5]. These are well-known as long-lived RONS and are stable in water; thus, a conventional UV-Vis spectrophotometry can precisely measure the RONS by comparing the absorption profiles of standard solutions, H_2O_2, $NaNO_2$, and HNO_3. On the other hand, short-lived RONS such as OH• and O_2^-• are relatively difficult to measure the absolute number. Measurement requires large-scale equipment, such as the laser-induced fluorescence (LIF) method [6]. Recently, we have developed a very simple method using conventional UV-vis spectrophotometry with dye solutions of unsaturated methylene blue (MB) and indigo carmine (IC) [7,8]. In addition, we are also investigating a couple of spin trap reagents for use in the colorimetric method, such as carboxy-PTIO for •NO [9,10].

In the presentation, we will show how we developed UV-vis spectrophotometry to investigate both long- and short-lived RONS.

This work was supported by KSAC (Kansai Startup Academia Coalition) and JSPS/MEXT KAKENHI. JSOH thanks Prof. Akimitsu Hatta of Kochi Univ. Technol. and Prof. Masafumi Ito of Meijo Univ. for their support.

References

[1] J.-S. Oh et al., *J. Phys. D: Appl. Phys.* **44** 155206 (2011).

[2] J. W. Bradley et al., *IEEE Trans. Plasma Sci.* **39** 2312 (2011).

[3] J.-S. Oh et al., *Jpn. J. Appl. Phys.* **57** 0102B9 (2018).

[4] E. J. Szili et al., *J. Phys. D: Appl. Phys.* **48** 202001 (2015).
[5] J.-S. Oh et al., *J. Phys. D: Appl. Phys.* **49** 304005 (2016).
[6] I. Yagi et al., *Plasma Sources Sci. Technol.*, **24**, 015002 (2015).
[7] Y. Torii et al., *ISPlasma2023/IC-PLANTS2023*, Gifu, Japan.
[8] Y. Jonen et al., *ICPM 11 & IWPCT10*, Gifu, Japan.
[9] U. Samuni et al., *J. Am. Chem.* **132** 8428 (2010).
[10] S. Goldstein et al., *J. Biological Chem.* **278** 50949 (2003).

Invited Lecture

Differential Roles of Atomic Oxygen and Ozone in Germination Enhancement and Protein Modification of Rice Seeds

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Non-thermal atmospheric-pressure air plasmas have gathered considerable attention as an innovative tool for sustainable agriculture, particularly in accelerating seed germination and plant growth [1–3]. However, because air plasmas simultaneously generate complex mixtures of various reactive oxygen and nitrogen species (RONS), identifying the specific reactive species responsible for biological activation remains a critical unresolved issue in plasma agriculture [1,2]. In this study, the individual roles of short-lived atomic oxygen (O atom) and long-lived ozone (O_3) in modulating the germination behavior of rice seeds (Oryza sativa L. cv. Nipponbare) have been discussed [1]. Using a vacuum ultraviolet photodissociation reactive species supply (VUV-PRS) system for selective and quantitative irradiation [1,4], rice seeds were exposed to low-concentration O atoms (0.74 ppm) [1]. Our findings revealed that O atom treatment markedly enhanced the germination percentage and germination index (GI) [1]. Dose-dependent evaluations demonstrated a clear optimal treatment window (O atom dose around 7.7×10^{18} to 1.1×10^{19} molecules cm^{-2}), beyond which excessive irradiation suppressed germination [1]. In contrast, selective exposure to O_3 alone up to 400 ppm showed no noticeable effect on germination [1]. Protein oxidation analysis using SDS-PAGE indicated that O atom irradiation specifically induced protein carbonylation in key seed storage proteins (around 25 kDa), whereas O_3 caused negligible changes [1,5]. These results strongly suggest that highly reactive O atoms serve as a key initiator of biological responses in plasma-treated seeds through targeted oxidative modifications [1,5].

Acknowledgement:

The author sincerely thanks Profs. A. Higashitani (Tohoku U.), T. Kawasaki (Nishinippon Inst. Technol.), and R. Ono (U. Tokyo) for their valuable collaboration and fruitful discussions. This work was supported in part by the Plasma-Bio Consortium project, JSPS KAKENHI Grant Nos. JP24H02246, JP24H02250, JP24H02248, JP25H02207, JP25H02217. The author also thanks Prof. Tsugane of the IBBP Center, NIBB, for providing the rice seeds.

References

[1] H. Shi, C. Wang, N. Hidaka, T. Okumura, P. Attri, K. Koga, M. Shiratani, A. Higashitani, N. Higashitani, T. Kawasaki, and R. Ono, Appl. Phys. Express, 19, 021007 (2026).

[2] T. Okumura, T. Anan, H. Shi, P. Attri, K. Kamataki, N. Yamashita, N. Itagaki, M. Shiratani, Y. Ishibashi, K. Koga, and V. Mildažienė, Appl. Phys. Express, 17, 057001 (2024).

[3] S. Kitazaki, T. Sarinont, K. Koga, N. Hayashi, and M. Shiratani, Curr. Appl. Phys., 14, S149 (2014).

[4] H. Du, A. Komuro, and R. Ono, Plasma Sources Sci. Technol., 32, 075013 (2023).

[5] K. Oracz and M. Stawska, Front. Plant Sci., 7, 1128 (2016).

Invited Lecture

Breaking the Well-Mixed Assumption in Closed Air Plasma Reactors: Thermal Stratification Governs O_3-to-NO_x Chemistry

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Surface dielectric barrier discharge (sDBD) reactors operated in air have been widely investigated for environmental, agricultural, and plasma-activated liquid applications.[1–3] In closed or batch-type reactors, plasma operation simultaneously generates reactive species, heat, and gas circulation, resulting in spatially nonuniform physicochemical environments. Nevertheless, gas-phase plasma chemistry is commonly interpreted using a spatially averaged reaction volume, potentially obscuring local thermal and transport phenomena that critically influence the generation, redistribution, and conversion of reactive species.[4] In particular, the role of spatially nonuniform heating in regulating the temperature-sensitive competition between O_3- and NO_x-dominated reaction pathways remains insufficiently understood in closed sDBD reactors. Here, we investigate the coupling between discharge-induced gas heating, internal transport, and O_3–NO_x chemistry in a closed air reactor. Top- and bottom-discharge configurations were compared under otherwise identical electrical and geometric conditions. Spatially resolved optical absorption spectroscopy was employed to monitor the temporal evolution of O_3, N_2O_5, NO, and NO_2 at eight vertical positions. Infrared thermography, thermocouple measurements, and particle image velocimetry were additionally used to characterize the temperature distribution and gas-flow field within the reactor. In the top-discharge configuration, intense localized heating near the plasma source produced pronounced thermal stratification, with a vertical temperature difference of up to 84.4 °C. The resulting spatially nonuniform thermal environment was accompanied by a position-dependent transition from O_3-dominated to NO_x-dominated chemistry, with transition times ranging from approximately 185 to 233 s along the reactor height. By contrast, the bottom-discharge configuration promoted more effective heat redistribution, reduced thermal stratification, and maintained an O_3-rich environment throughout the same operating period. Repeated operation in the top-discharge configuration further

revealed a thermal-memory effect, which progressively accelerated the O_3-to-NO_x transition by approximately 90 s over four consecutive cycles. These results demonstrate that localized gas heating and the associated thermal transport are key determinants of the spatiotemporal evolution and selectivity of reactive species in closed air plasma reactors. The findings underscore the importance of resolving coupled thermal, transport, and chemical fields, rather than relying exclusively on volume-averaged descriptions, when interpreting plasma chemistry and designing closed sDBD systems.

This research was supported by the National Research Council of Science & Technology (NST) grant by the Korea government (MSIT) (No. GTL25101-000).

References

[1] H.J. Kim et al, *Molecules* **28**, 1-12 (2023).

[2] J.Y. Park et al, *Plasma Chem. Plasma Process.* **45**, 297-311 (2025).

[3] J. H. Bae et al, *Plasma Chem. Plasma Process.* **46**, 21 (2026).

[4] B. Tarabová et al, *Plasma Process. Polym.* **15**, 1800030 (2018).

Invited Lecture

From Plasma-Activated Water to Plasma-Activated Hydrogel: Advancing Stable Plasma Therapeutics for Biomedical Applications

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Plasma-activated water (PAW) has been widely explored as a chemical-free antimicrobial platform due to its ability to generate reactive oxygen and nitrogen species (RONS) with broad biological activity. In our earlier research, PAW was investigated as an alternative approach for microbial inactivation, particularly in food and biological surface applications, where plasma-generated reactive species could contribute to safer and more sustainable antimicrobial processes. However, practical translation of PAW remains challenged by the transient stability of reactive species, limited contact time, and difficulty in applying liquid formulations to irregular or mobile biological surfaces. Motivated by these limitations and by collaborative clinical needs from veterinary wound-care applications, our recent work has advanced PAW into plasma-activated hydrogel (PAH), a plasma-enabled biomaterial designed to retain reactive species and improve localized delivery. This invited talk presents the evolution of our research from PAW-based antimicrobial treatment toward PAH as a more stable and applicable platform for infection control. A gelatin-based PAH was developed using PAW generated from a nanobubble-assisted non-thermal plasma system and evaluated for physicochemical stability, reactive species retention, and inhibition of Staphylococcus aureus relevant to animal skin infection. The PAH matrix improved reactive species retention compared with PAW alone and demonstrated strong antimicrobial activity, supporting its potential as a chemical-free dressing or topical formulation for veterinary wound management. This work highlights how plasma-derived liquids can be transformed into functional biomaterials through process and formulation engineering, bridging plasma chemistry, biomedical application, and real-world translational needs in plasma bioscience.

Keywords: Plasma-activated water; Plasma-activated hydrogel; Reactive oxygen and nitrogen species; Veterinary wound care; Plasma-enabled biomaterials

Invited Lecture

Cold Plasma in Clinical Treatment at Tuệ Tĩnh Hospital, Vietnam

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The role of cold plasma in medical therapy has been widely discussed; however, to date no report has described its application in the clinical treatment of patients. Tuệ Tĩnh Hospital – the practice hospital affiliated with the Vietnam University of Traditional Medicine – has, for the first time, applied cold plasma in clinical treatment and recorded the following results. Treatment was carried out over 28 days, with each cold plasma irradiation session lasting 15 minutes, delivered three times per day. The study was conducted from September 2025 to January 2026.

– One patient with knee osteoarthritis and one patient with right shoulder periarthritis: pain symptoms were reduced after plasma irradiation compared with before treatment.

– One patient with an open wound following Milligan–Morgan hemorrhoidectomy: reduced pain, decreased exudation, and reduced inflammation, with faster wound healing after two weeks of cold plasma irradiation.

– One patient with diabetes presenting a chronic foot-ulcer complication.

– One patient with acne vulgaris: cold plasma irradiation combined with topical application of the herbal facial remedy “Ích Nhan Tuệ Tĩnh”.

Liver and kidney function were normal both before and after the 28-day course of plasma treatment. No adverse effects were observed following cold plasma irradiation.

Keywords: Cold plasma

Invited Lecture

Nano-Redox Pathology and Triadic Biological Effects of Cold Atmospheric Plasma: A Theoretical Framework for Translational Plasma Medicine

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Cold atmospheric plasma (CAP) has emerged as a non-thermal biomedical technology with potential relevance to wound healing, infection control, dermatology, inflammation modulation, tissue repair, and cancer-related research. Despite rapid development in plasma medicine, the biological interpretation of CAP remains fragmented. In different contexts, CAP is described as an antimicrobial intervention, a wound-healing modality, an inflammation-modulating technology, or a potential anticancer approach. These application-based descriptions are useful, but they do not fully explain how a single physical technology can be associated with apparently divergent biological outcomes. This report presents the first-stage theoretical outcome of an interdisciplinary Vietnamese collaboration among the Thang Long Institute of Cognition and Education, Tue Tinh Hospital, and the Institute of Materials Science, Vietnam Academy of Science and Technology. On the basis of literature synthesis, preliminary clinical observations, plasma-physical reasoning, and interdisciplinary conceptual integration, we propose the framework of “nano-redox pathology and triadic biological effects of cold atmospheric plasma.” The central proposition is that CAP should be understood as an electron-initiated, non-equilibrium perturbation system whose biological effects depend on the pre-existing state of the target tissue, cell, or microenvironment. Beneath conventional cellular and molecular pathology, we propose a subcellular pathological layer involving redox imbalance, mitochondrial reserve, membrane potential, surface charge, lipid oxidation, calcium regulation, antioxidant buffering, plasma–liquid interfacial chemistry, and immune-recognition signaling. We refer to this layer as nano-redox pathology. Within this framework, CAP may generate three state-dependent biological effects: reparative modulation, selective destabilization, and immunologic unmasking. In injured or infected tissues with preserved reparative capacity, CAP may support antimicrobial control, inflammation modulation, and tissue repair. In redox-vulnerable pathological cells, particularly malignant cells, CAP-induced perturbation may exceed adaptive thresholds and promote mitochondrial dysfunction, apoptosis, loss of clonogenic survival, or other forms of pathological destabilization. In immune-evasive tumor states, CAP may also contribute to the exposure of danger or recognition signals. This report does not claim that CAP is an established cancer treatment. It proposes a testable theoretical framework intended to guide CAP device standardization, biomarker selection, experimental validation, and future translational research.

Keywords: Cold plasma,Cancer therapy

Invited Lecture

Plasma-Activated Water and Its Application In Medicine And Agriculture

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Abstract

Surgical site infections are among the most prevalent postoperative complications and remain a pressing global health challenge, exacerbated by the rise of antimicrobial resistance. Plasma-activated water (PAW) is an emerging antimicrobial agent, but conventional PAW requires acidic pH for efficacy. We previously developed a high-strength, neutral-pH bicarbonate-buffered PAW (hs-PAbW) that retains potent antimicrobial activity while being clinically suitable. This study evaluated the efficacy of hs-PAbW-20-gel as a topical antimicrobial agent that simultaneously eradicates wound infections and promotes healing. The hs-PAbW was formulated at a bactericidal yet non-cytotoxic 20% concentration into a xanthan gum hydrogel (hs-PAbW-20). Its efficacy was evaluated in full-thickness excisional wound models in Balb/c and C57BL/6 mice infected with Pseudomonas aeruginosa or Staphylococcus aureus. Treatments (hs-PAbW-20-gel, control gel, or commercial antibiotics neomycin/soframycin) were applied topically. Wound closure, bacterial burden, expression of key healing genes (Pdgf, Egfr, Mmp1/3) by RT-qPCR, and histopathology (H&E staining) were assessed. A streptozotocin-induced diabetic C57BL/6 model was also tested. In Balb/c mice, hs-PAbW-20-gel significantly reduced P. aeruginosa and S. aureus burden, achieving results comparable to neomycin and soframycin treatments. This gel also accelerated wound closure by modulating genes crucial for wound repair. In diabetic C57BL/6 mice, hs-PAbW-20-gel decreased the burden of P. aeruginosa and promoted faster healing. The hs-PAbW-20-gel is a promising topical therapeutic that

combines potent antimicrobial activity with active promotion of wound repair, offering a superior alternative to conventional antibiotic ointments.

This talk also discusses the application of PAW for agricultural applications.

Funding: Supported by DAE, DBT, DST, ICMR, UGC, MHRD, and CSIR (India).

Broad Area: Plasma-activated water, medicine, wound healing, agriculture

Invited Lecture

High Voltage Power Sources for Plasma and Electric field Processing

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Over the past 20 years, several kinds of high voltage power sources have been developed and introduced to industries. Three phase high voltage transformer rectifiers have been applied to over 100 industrial electrostatic precipitators and/or streamer corona plasma for low particle matter and NOx emission control. 50-100kW dielectric barrier discharge plasma have been applied for bioaerosols, odor gases, waste water and soil contamination cleaning. 1kJ-50kJ/pulse all solid switch power sources have been world widely used for seismic applications and they can be also used for food processing and water sterilization and disinfection. Multi-plasma jets of up to 81 sources have been used for bioaerosols or viruses cleaning and wound healing. One nanosecond novel high voltage power source is under clinical testing for tumor ablation. This presentation discusses the state of the art of our R&D progresses.

Invited Lecture

Cold Atmospheric Plasma as an Adjunctive Preventive and Therapeutic Approach for Radiation Dermatitis: A Observational Case Series

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Acute radiation dermatitis is a frequent and clinically relevant toxicity of radiotherapy, particularly in head and neck cancer, and may impair quality of life, increase pain and local inflammation, require intensified supportive care, and in severe cases contribute to treatment interruptions [1]. Current guidelines emphasize structured prevention and management strategies, yet additional non-invasive supportive interventions remain needed [2]. Cold atmospheric plasma (CAP) has documented antimicrobial, inflammation-modulating, and tissue-regenerative effects in wound care and may therefore represent a biologically plausible adjunctive approach for radiotherapy-associated skin toxicity [3].

We report an observational case series of six patients with malignant head and neck tumors undergoing curatively intended percutaneous radiotherapy or brachytherapy (January-July 2026). All patients received standard topical supportive skin care. CAP was applied as an adjunctive, non-invasive intervention on treatment days, approximately 30 minutes to 3 hours after irradiation, both therapeutically, for established radiation dermatitis, and preventively, after individual fractions. Skin reactions were assessed using the Radiation-Induced Skin Reaction Assessment Scale (RISRAS), complemented by patient-reported and clinician-observed changes in erythema, inflammation, burning, pain, and overall discomfort.

Adjunctive CAP was feasible and well tolerated in all six patients. In one patient with pronounced radiation dermatitis after irradiation for oropharyngeal carcinoma, CAP was associated with rapid improvement of inflammation and visible radiodermatitis (Fig. 1). In patients receiving CAP preventively after individual fractions, plasma appeared to help limit progression to more pronounced dermatitis. The intervention was associated with improved subjective tolerability and may support quality of life during radiotherapy. These preliminary observations suggest that adjunctive CAP could potentially reduce treatment interruptions caused by severe radiation dermatitis; this hypothesis requires confirmation. Given the small, uncontrolled, observational design, findings are hypothesis-generating.

These observations provide the clinical rationale for a prospective, randomized, multicenter trial, the CAPRAD study, planned with centers in Lübeck (Germany), Milan (Italy), and Muscat (Oman), to systematically evaluate preventive CAP treatment for radiation dermatitis during radiotherapy.

Fig. 1. Clinical course of pronounced radiation dermatitis after radiotherapy for oropharyngeal carcinoma, showing improvement under adjunctive cold atmospheric plasma treatment (begin of treatment to 2 weeks). Representative case from this observational series.

Acknowledgement: The authors thank the patients and the clinical staff of Center for Clinical Plasma Research and Therapy, UKSH Campus Lübeck for their support. [Funding: UKSH Förderstiftung].

References

[1] T. Behroozian et al., Lancet Oncology, 24, e172–e185 (2023).

[2] R. Noble-Adams, British Journal of Nursing, 8, 1308–1311 (1999).

[3] G. Isbary et al., British Journal of Dermatology, 167, 404–410 (2012).

Invited Lecture

Nitric Oxide and Redox Signaling in Plants; From Molecular Mechanisms to Plasma-Activated Water

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Nitric oxide (NO) is a redox-active signaling molecule that regulates plant growth, development, immunity, and environmental stress adaptation. A major mechanism underlying NO bioactivity is protein S-nitrosylation, the reversible addition of an NO moiety to a cysteine thiol. Our earlier work demonstrated that S-nitrosylation of the NADPH oxidase AtRBOHD at Cys890 suppresses reactive oxygen species production, establishing a negative-feedback mechanism that limits pathogen-induced hypersensitive cell death [1]. Subsequent transcriptomic and functional-genomic studies revealed that NO-responsive networks encompass transcriptional regulation, hormone signaling, metabolism, and biotic and abiotic stress responses [2].

We recently investigated the interaction between S-nitrosoglutathione (GSNO) homeostasis and jasmonic acid (JA) signaling during light-induced anthocyanin production. Under continuous light, the GSNOR1 loss-of-function mutant gsnor1-3 and the JA-insensitive mutant coi1 showed reduced anthocyanin accumulation, whereas the GSNOR1 gain-of-function mutant gsnor1-1 displayed enhanced JA-dependent pigmentation. These findings indicate that GSNOR1 coordinates GSNO, JA, and ROS homeostasis to regulate anthocyanin biosynthesis and photoprotection [3]. Our bioRxiv study extends this concept to oxygen sensing and flooding adaptation. Genetic and computational analyses support a model in which elevated NO/GSNO promotes S-nitrosylation of the conserved N-terminal Cys2 of group-VII ETHYLENE RESPONSE FACTORs, facilitating their interaction with N-degron pathway components and influencing ERFVII stability, hypoxia-responsive transcription, and cellular energy homeostasis [4]. Building on these insights, we will examine how plants perceive NO-enriched plasma-activated water. We will characterize its reactive nitrogen and oxygen species and determine how dose, exposure duration, and genotype influence GSNO metabolism, protein S-nitrosylation, ROS–NO crosstalk, growth, and stress tolerance. This approach may bridge plasma chemistry and plant redox biology and support biologically controlled plasma applications in agriculture.

This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (RS-2023-00245922).

References

[1]B-W Yun et al., Nature, Volume, Page (2011).

[2]A. Author, Title of Book, Publisher, City (2016).

[3]G-J Lee et al., Environmental and Experimental Botany 249, 106415 (2026).

[4]A.K Das et al., bioRxiv [Preprint] DOI https://doi.org/10.64898/2026.07.28.741153 (2026).

Invited Lecture

Cold Atmospheric Plasma Technology for Biomaterials Design: Liquid–Liquid Phase Separation Driven Self-Assembly of Biomolecules

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Cold atmospheric plasma (CAP) has emerged as a powerful platform in plasma bioscience due to its ability to generate tunable reactive oxygen and nitrogen species (RONS) under ambient conditions. While CAP has been widely investigated for wound healing, sterilization, and cancer therapy, its potential to direct biomolecular self-assembly for functional biomaterials design remains largely unexplored. In this presentation, we introduce cold plasma-induced liquid–liquid phase separation (P-LLPS) as a mechanistic framework that connects plasma chemistry with biomolecular condensation and supramolecular assembly.

Our laboratory demonstrates that CAP acts as a programmable physicochemical stimulus, modulating weak intermolecular interactions, including hydrogen bonding, electrostatic interactions, hydrophobic effects, and π–π stacking, to induce transient biomolecular condensates. These condensates subsequently evolve into ordered fibrillar networks and hydrogels with tailored structural and functional properties. Using simple biomolecules such as amino acids, Fmoc/Boc modified amino acids and peptides as model systems [1-4], we show that controlled plasma treatment regulates nucleation kinetics, assembly pathways, and material architecture through precise control of plasma operating parameters.

Importantly, CAP enables gelation at significantly lower critical gelation concentrations (CGC) compared with conventional chemical approaches while eliminating the need for toxic crosslinkers. This solvent-free and environmentally benign strategy provides a versatile route for engineering biomaterials with tunable functionality.

The concept of P-LLPS establishes a new paradigm in plasma-enabled biomaterials research by integrating plasma physics, supramolecular chemistry, and soft matter science. This emerging approach opens new opportunities for the development of programmable hydrogels, bioactive scaffolds, drug delivery systems, and regenerative biomaterials, positioning CAP as a sustainable manufacturing technology for next-generation biomaterials with programmable structure, function, and translational potential.

This work was supported by DST-IASST In-house Grant and ICMR-ITR Grant.

References

[1] D. Basumatary, K. Sankaranarayanan, et al. Langmuir 41, 12052–12063 (2025).

[2] P. Bhatt, K. Sankaranarayanan, et al. Phys. Chem. Chem. Phys. 27, 24969 (2025).

[3] D. Basumatary, K. Sankaranarayanan, et al. *J. Phys. D.* **57**, 285402 (2024); *RSC advances* **13**, 26640 (2023).

[4] R. Zende, A.J. Bharati, K. Sankaranarayanan *Plasma Processes and Polymers* 22, 2400172 (2025).

Invited Lecture

Engineering Reactive Species Biology: Translational Applications of Cold Atmospheric Plasma Across Plant, Infection, and Cancer Models

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Cold Atmospheric Plasma (CAP) has emerged as a promising redox-based technology capable of generating tunable reactive oxygen and nitrogen species (RONS) with broad applications in agriculture, infection control, regenerative medicine, and oncology. Our studies at the Redox Lab, Sri Ramachandra Institute of Higher Education and Research (SRIHER), demonstrate that CAP-induced biological responses are strongly influenced by feed-gas composition and the resulting RONS profiles.

In agricultural models using *Allium cepa*, argon-based CAP significantly enhanced root proliferation, root elongation, and mitotic activity, indicating growth-promoting effects mediated through controlled oxidative signaling. In contrast, helium CAP induced a pronounced stress-associated metabolic response characterized by increased production of volatile and semi-volatile bioactive compounds identified through gas chromatographic profiling. These findings underscore the ability of CAP to differentially regulate plant growth and metabolite production.

We further investigated CAP for antimicrobial and wound-healing applications targeting diabetic foot ulcers (DFUs), where antimicrobial resistance, biofilm formation, and bacterial persistence compromise treatment outcomes. Using optimized plasma feed-gas combinations generating distinct RONS signatures, argon + oxygen CAP demonstrated superior antimicrobial activity against clinical Gram-positive and Gram-negative DFU isolates. CAP exposure significantly disrupted biofilm architecture, reduced bacterial viability, and effectively eliminated antibiotic-tolerant persister cells in a dose-dependent manner. Importantly, CAP treatment up to 60 s did not induce significant cytotoxic or genotoxic effects in peripheral blood mononuclear cells, supporting its translational potential for chronic wound management.

In cancer models, low-dose argon CAP altered extracellular heme homeostasis and enhanced bleomycin sensitivity through an iron-dependent mechanism. CAP preconditioning resulted in more than five-fold reductions in bleomycin IC50 values, whereas deferoxamine abrogated this synergistic effect. Notably, normal keratinocytes and PBMCs exhibited lower sensitivity under comparable exposure conditions.

Collectively, our findings establish CAP as a multifunctional translational platform capable of modulating redox biology across diverse biological systems with applications in sustainable agriculture, antimicrobial therapy, wound healing, and precision oncology.

Acknowledgement: This work is supported by Department of Biotechnology (DBT) Grant No. BT/PR44553/MED/30/2391/2021 and Indian Council of Medical Research (ICMR) Grant No. IIRPSG-2024-01-00024,

References:

Murali R, Singh P, Ragunathan D, Gandhirajan RK, et al. Antimicrobial Activity of Cold Atmospheric Plasma on Bacterial Strains Derived from Patients with Diabetic Foot Ulcers. J Microbiol Biotechnol. 2024;34(11):1-9.2.

Roopak Murali RE, Joanna Pauline Samuel, Pooja Singh, Shivangi Saha, Maneesh Singhal and Rajesh Kumar Gandhirajan. Cold Atmospheric Plasma (CAP) in Wound Healing: Harnessing A Dual Edged Sword. Redox Experimental Medicine. 2023;1(1).

Invited Lecture

Properties of Nitric Oxide in blood and its influences on our health

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Nitric oxide (NO) could react with oxygen molecules in water including blood, converting to nitric dioxide (NO_2). A detailed theoretical analysis is presented and compared with experimental data reported by Professor Byoungchoo Park. Thus, eliminating oxygen from water before injecting nitric oxide is crucial for decay time increase of nitric oxide in water. The effect of HClO (hypochlorous acid) on the decay properties of nitric oxide is also reported in this presentation, showing that nitric oxide remains hidden from oxygen via HClO and gradually emerges later. Remember that the tap water contained hypochlorous acid in our water supply system. The most dominant gas emitted from discharge pond of pig farm could be ammonia (NH_3), which is strong-pungent odor. Nitric oxide in water could eliminate ammonia in water. Ammonia in an isolated space could also be eliminated by spray of nitrite water.

Typical hemoglobin concentration in blood is approximately 120,000 to 180,000 ppm (parts per million) by mass. Free oxygen concentration in blood is about 4 ppm in number of molecules, which is slightly less than tap water (5ppm). Nitric oxide may form nitrate (NO_3) with free oxygen molecules. The nitrate could eliminate ammonia (NH_3) in blood. Gout is caused by too much uric acid in the blood (hyperuricemia), which forms sharp crystals in joints, triggering sudden pain, redness, and swelling. This buildup happens when the body produces too much uric acid or the kidneys couldn't remove it efficiently, influenced by genetics, diet (red meat, shellfish), alcohol, obesity, certain meds (aspirin), and conditions like high blood pressure, kidney disease, or diabetes. Purines in blood may form uric acid with oxygen molecules, but nitric oxide (NO) could form nitrate (NO_3) in blood which has a strong affinity to hydrogen atoms to form nitrate acid (HNO_3). Therefore, in the process of forming uric acid from purines and oxygen, nitrate (NO_3) interferes by stealing hydrogen atoms from purines, eventually not forming uric acid and resulting of gout remediation.

Invited Lecture

Brief Report of IEC60601-2-91, WG41,TC62D “Particular requirements for the basic safety and essential performance of non-thermal plasma wound treatment equipment”

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Abstract

Brief report will be discussed to all experts and industries in plasma medicine for “particular requirements for the basic safety and essential performance of non-thermal plasma wound treatment equipment” in IEC (International Electrotechnical Commission) SC62D under the IEC60601-2-91. This work has been proposed by PWI (prerequisite work item) at IEC 82nd meeting, 2019, in Shanghai, China. Throughout the ahG40 virtual meeting at January and February, 2020, the new work item proposal (NWIP) has been submitted to IEC SC62D, August, 2021, which leads to NP (New proposal) with establishment of working group WG41 in December, 2021. The CD (Committee draft) has been passed at April 21, 2023 for the preparation of CDV (Committee draft voting). The FDIS (Final draft international standard) has been approved at May 15, 2026 through the 1st CDV by 83.3% at July 1, 2024 and the 2nd CDV by 100% at February 17, 2025, respectively. Finally IS (International Standard) publication IEC60601-2-91 in WG41 has been done at July 20, 2026 throughout the FDIS editing works since April 3, 2026 to May 15, 2026.

Invited Lecture

Effect of Atmospheric Pressure Cold DBD Plasma on Seed Germination and Crop Yield of Sticky Rice and White Rice Varieties during the Wet Season

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Abstract

Atmospheric pressure cold plasma (APCP) has emerged as a promising non-chemical and environmentally friendly technology for sustainable agriculture, particularly for improving seed performance and crop productivity. This study evaluated the effects of air-based dielectric barrier discharge (DBD) plasma treatment on seed germination, seedling growth, and crop yield of sticky rice varieties RD22, RD26, and SP1 (Sanpatong 1), as well as the white rice variety RD79 (Chai Nat 62) (Oryza sativa L.) during the wet season. Experiments were conducted at *Maejo University Phrae Campus* using a DBD plasma system operated under ambient air conditions. Reactive plasma species generated during treatment were identified and characterized by optical emission spectroscopy (OES). Rice seeds were exposed to plasma for 30, 60, 90, 120, and 150 min prior to sowing, and their performance was compared with untreated controls. Preliminary results showed that plasma-treated seeds exhibited improved germination, enhanced seedling vigor, and higher crop yield relative to untreated seeds. These improvements may be associated with plasma-induced physiological seed activation and the action of reactive oxygen and nitrogen species produced during treatment. The findings indicate that atmospheric pressure cold DBD plasma has strong potential as a chemical-free seed treatment technology for enhancing rice production and supporting sustainable agricultural innovation.

Keywords: atmospheric pressure cold plasma, dielectric barrier discharge (DBD), seed germination, sticky rice, white rice, crop yield, plasma agriculture

Invited Lecture

Plasma-Enabled Interfacial Engineering: A Sustainable Pathway Toward Next-Generation Materials

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Interfacial properties play a pivotal role in determining the performance and durability of advanced composite materials. Conventional surface modification methods often involve harsh chemicals, limited control, and undesirable changes to bulk properties. Plasma-enabled interfacial engineering has emerged as a clean, versatile, and highly controllable approach for tailoring surface chemistry and morphology while preserving intrinsic material characteristics.

This presentation highlights plasma-assisted surface engineering for next-generation composite materials in environmental remediation and sustainable energy applications. Plasma–surface interactions, including activation, etching, and functional group incorporation, together with optical emission spectroscopy diagnostics, are discussed. Applications include plasma-modified activated carbon felts for heavy metal adsorption, oil–water separation, and VOC removal, as well as plasma-treated hybrid electrocatalysts for enhanced water-splitting performance. Overall, plasma-enabled interfacial engineering provides a scalable and sustainable strategy for developing multifunctional composite materials bridging plasma science with environmental and energy technologies.

Keywords: Plasma-enabled interfacial engineering; Plasma surface modification; Composite materials; Activated carbon felt; Heavy metal adsorption; Oil–water separation; VOC removal; Electrocatalysis; Water splitting.

Invited Lecture

Humidity and Temperature Effects on Plasma Chemistry Dynamics in a Parallel-Plate DBD Source

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Non-thermal atmospheric plasma (NAP) has been widely studied in many fields, such as biology, agriculture, environmental science, semiconductors, surface modification, and sterilization, and has been applied across diverse industries. The NAP market was estimated at USD 2.44 billion in 2025 and is expected to exceed USD 8.66 billion by 2035, expanding at a compound annual growth rate (CAGR) of more than 13.5% during the forecast period, according to Research Nester. As an eco-friendly method, NAP is expected to become a driving force of future industries. The NO water device developed by Plasade Co., Ltd., established in August 2022 by Professor Eun Ha Choi of Kwangwoon University, has been selected as a product for the Public Procurement Service's Innovative Product Pilot Purchase Program. Through the Innovative Product Pilot Purchase Program, the Public Procurement Service is able to support the purchase costs of the NO water device and supply it to domestic and overseas public institutions with demand.

This study proposes a plasma-chemistry model for the active species generated by two parallel dielectric barrier discharge (DBD) plasma sources facing each other, together with a method that solves the simultaneous differential equations for species densities as functions of humidity and temperature using a zero-dimensional (0D) model. A high voltage of 7.5 kV at a frequency of 50 kHz was applied to the parallel-plate DBD plasma source in air. The duty cycle was 15%. The average reduced electric field E/N was 120 Td, and the electron density ranged from 4.4 to 6.3 × 10^{15} m^{-3} depending on humidity , obtained from the current density.

A set of 124 chemical reactions was used to compute the densities of 23 plasma species at 0%, 30%, and 70% humidity, by solving the coupled rate equations numerically using a Python-based 0D kinetic code. The dissociation and excitation rate coefficients for electron-impact reactions with molecules were calculated using LXCat and BOLSIG+. The experimental temperature of the parallel-plate DBD source was taken from G. Neretti's paper. The temporal evolution of the species densities with respect to humidity and temperature was calculated. At high temperature, ozone decomposes and NOx species accumulate, shifting the dominant chemistry.

References

[1] G. Neretti, M. Taglioli, and C. A. Borghi, *Eur. Phys. J. D* **72**, 113 (2018).

[2] Y. Sakiyama, D. B. Graves, H. W. Chang, T. Shimizu, and G. E. Morfill, *J. Phys. D: Appl. Phys.* **45**, 425201 (2012).

[3] L. Lin, Y. Lyu, B. Trink, J. Canady, and M. Keidar, *J. Appl. Phys.* **125**, 153301 (2019).

[4] S. Park, W. Choe and C. Jo, *Chem. Eng. J.* **352**, 1014 (2018)

Invited Lecture

Diagnostics and Simulation for Plasma Chemistry

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Atmospheric pressure plasmas are weakly ionized yet highly reactive physicochemical systems, in which electrons, ions, excited species, radicals, photons, heat, and interfacial charge accumulation are strongly coupled. This complexity makes diagnostics essential not only for characterizing plasma parameters, but also for understanding and controlling plasma-driven chemistry in biomedical, environmental, agricultural, and materials-related applications. In this talk, I will discuss diagnostic and simulation approaches for analyzing plasma chemistry in atmospheric pressure plasma systems, with a focus on the generation of reactive oxygen and nitrogen species (RONS) and plasma–liquid interactions. Electrical diagnostics provide basic discharge characteristics such as voltage, current, charge, and power, whereas optical diagnostics offer non-invasive access to plasma properties and chemical compositions. Optical emission spectroscopy is used to estimate rotational and vibrational temperatures, as well as to identify excited species. In contrast, laser-based diagnostics can provide information on atomic species density and ion velocity distributions. Attention will be given to optical absorption spectroscopy combined with spectral analysis based on the Beer–Lambert law, which enables in situ quantification of multiple absorbing species in O_3–NO_x gas mixtures. Using surface dielectric barrier discharge plasmas, the transition between O_3-dominant and NO_x-dominant chemistry can be interpreted in terms of gas composition, oxygen concentration, discharge condition, and post-discharge reaction kinetics. In parallel, numerical simulations, including plasma chemistry models and plasma–liquid multiphysics models, are introduced as complementary tools to interpret diagnostic results and predict experimentally inaccessible quantities. These models help clarify the roles of heat transfer, electric-field enhancement, electrohydrodynamic force, and various plasma-liquid interactions. By combining time-resolved diagnostics with validated simulations, this work aims to establish a quantitative framework for linking plasma parameters, reactive species chemistry, and interfacial dynamics, thereby providing guidelines for the atmospheric pressure plasma processes.

Invited Lecture

Autonomous Synthesis and Materials Informatics in Plasma Technology: Advancing Materials for Energy and Environmental Applications

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The discovery and optimization of functional materials remain slow and labor-intensive, bottlenecked by manual, trial-and-error experimentation. We present an autonomous laboratory (self-driving lab) that couples cold-plasma chemistry with materials informatics to accelerate the synthesis and characterization of metallic nanomaterials. The platform integrates automated liquid handling, a dielectric barrier discharge (DBD) cold-plasma reactor, in-line optical imaging, and UV-Vis spectroscopy under a central control system, enabling closed-loop experiments with minimal human intervention. Argon cold plasma generates reactive oxygen and nitrogen species (ROS/RNS) that act as green reducing and stabilizing agents, allowing room-temperature, reagent-lean synthesis of gold and platinum nanoparticles (< 100 nm) without the high temperatures or toxic reductants required by conventional routes [1,2].

Design-of-experiments and response-surface optimization were translated into executable robot protocols, and the system produces standardized, FAIR-compliant datasets linking plasma parameters (power, gas flow, exposure time) to nanoparticle size, optical (LSPR) response, and catalytic performance. Relative to manual workflows, the platform targets a ≥ 50% reduction in synthesis time, ≥ 30% lower chemical consumption, and throughput exceeding 50 samples per day, building toward a reference dataset of 1,000 characterized samples. By combining plasma-enabled green synthesis with high-throughput data generation and informatics, this approach offers a scalable route to catalysts and nanomaterials for energy conversion and environmental remediation, and a blueprint for data-driven, autonomous materials discovery [3].

This work was supported by the Vietnam Academy of Science and Technology under Grant no. CN4000.02/26-28.

References

[1] A. Aspuru-Guzik et al., Nat. Rev. Mater., 3, 5 (2018).
[2] M. Burke et al., Nature, 624, 570 (2023).
[3] M. D. Wilkinson et al., Sci. Data, 3, 160018 (2016).

Invited Lecture

Increasing Role of Antiviral Disinfectants in the Control of Emerging Viral Diseases

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New epidemics of viral diseases still go on even after official termination of SARS-CoV-2 pandemic which showed the actual total death toll of significantly higher, ranging from 18.5 million to 35.2 million. High risk emerging epidemics presently include Marburg, Ebola, and avian influenza viruses. These diseases are highly infectious diseases with high fatality which should be handled in P4 level facility. In addition to these viral diseases, Korea has same level of risk disease, namely hemorrhagic fever with renal syndrome(HFRS). Annual cases of HFRS in Korea are approximately 300 to 600 cases. HFRS mainly breaks out in the district of demilitarized areas between North and South Korea, The causative agent was discovered in Hantan river area. Historically, humankind has solved pandemics using both of vaccine/antivirals together with disinfectants. However, it has become very difficult to control those emerging viruses because many recent emerging viruses showed high mutations mostly by RNA viruses which made conventional vaccine or antivirals useless.

Therefore, the use of disinfectants must be complemented for the effective control of emerging viral diseases. We found that dielectric barrier discharge plasma generated reactive nitrogen species showed highly effective against many viruses including SARS-CoV-2 with many practical advantages. When human coronavirus-229E strains were employed for viral inhibition using nitric oxide (NO) water in cell culture system, the virus showed significant decrease of cytopathic effects in the range of no toxic level of NO water to the host cell line. In addition, NO water is known to have many other beneficial effects to the related cells and immune reactions. However, NO gas in water has present only certain period of time. In addition, it shows dual functions which include toxic and beneficial effects depending on concentrations of the specimens. Therefore, many factors should be solved for the successful developments of drugs, diagnostics or hygienic product. These include control of nitric gas concentration in environments, reliable measurement of nitric oxide function and protocol establishment for consumer use. In conclusion, most successful control of many emerging viral diseases will be possible by effective use of disinfectants like NO water together with conventional vaccine/antiviral drugs.

References

[1] S. Ashokkumar, Nagendra Kumar Kaushik, Y. Shin, and E. Choe, Int. J. Mo. Sci. 24, 14106 (2023)

[2] World Health Organization, dashboards/covid19/cases, World, 28 days to 5 July (2026)

[3] G. Kampf, D. Todt, S. Pfaender, E. Steinmann, J. Hop. Infect, 104, (2020)

[4] L. Guo. R. Xu, Z. Lju, Y. Zgaim et al. Appl. Env Mic. 17, (2019)

[5] M. Sahun, A. Lin, L. Vande Heyden, et al. ACS Sustainable Chem. Eng. Eng. J. 11, (2023)

Invited Lecture

Plasma-Activated Media Stimulate Osteogenic Differentiation in Osteoblasts via ROS-Mediated WNT Signaling: A Novel Approach for Bone Regeneration

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Abstract

Nonthermal atmospheric plasma (NTP) has emerged as a promising tool for modulating cellular behavior by generating reactive oxygen and nitrogen species (RONS). Yet, its potential to stimulate osteogenic activity via indirect, medium-mediated exposure remains underexplored. In this study, two nonthermal plasma sources, dielectric barrier discharge (DBD) and jet nonthermal plasma (JNTP), were used to treat serum-free culture medium, generating plasma-activated media through ion exchange at the plasma-liquid interface. Physicochemical characterization revealed time-dependent increases in hydrogen peroxide and nitrite concentrations, along with changes in pH, conductivity, and oxidation-reduction potential, confirming the generation of a reactive aqueous microenvironment. Among the tested conditions, 25% jet NTP-treated medium (JNTPM) induced maximum alkaline phosphatase activity in SaOS-2 osteoblasts without compromising cell viability or inducing cytotoxicity. JNTPM treatment upregulated mRNA and protein expression of key osteogenic markers, including Runx-2, Osterix, collagen 1α, bone sialoprotein, and osteocalcin, and enhanced collagen synthesis and mineralization. Mechanistically, JNTPM activated the WNT signaling pathway, evidenced by increased Axin-2 reporter activity, β-catenin stabilization, and GSK-3β phosphorylation, while showing no effect on BMP/Smad signaling. JNTPM also elevated intracellular reactive oxygen species (ROS) in osteoblasts, and pretreatment with the antioxidant N-acetyl-L-cysteine attenuated WNT pathway activation, establishing ROS as an upstream mediator of plasma-induced osteogenesis. These findings demonstrate that plasma-activated media can stimulate osteoblast differentiation through ROS-dependent activation of WNT signaling, offering a novel, cell-contact-free strategy for bone regeneration. This work highlights the therapeutic potential of plasma-liquid interface chemistry in orthopedic and regenerative medicine applications, bridging plasma bioscience with skeletal tissue engineering.

Keywords: Osteoblasts, Nonthermal plasma, Reactive oxygen species, WNT signaling pathway, osteogenic activity

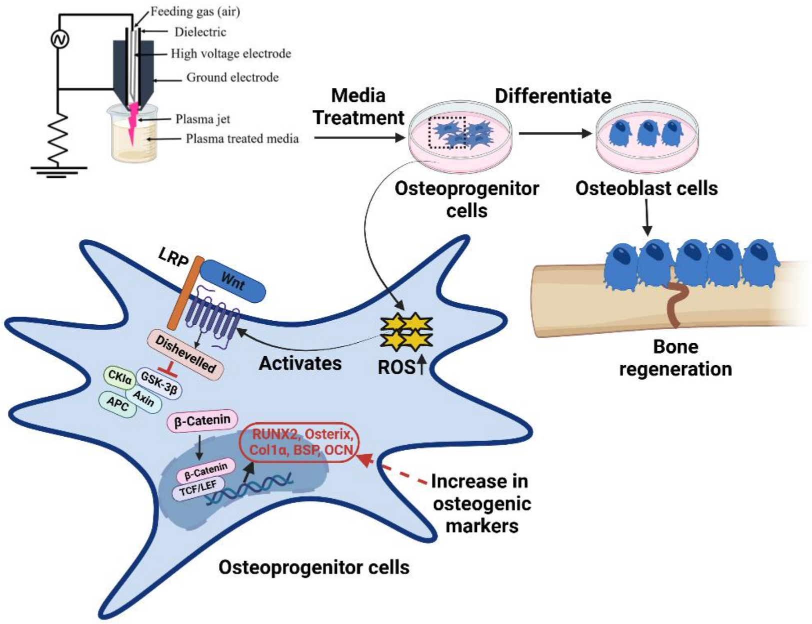

Figure 1. Graphical abstract representing the mechanism of action of nonthermal plasma in inducing osteogenic activity in osteoblasts.

Acknowledgement

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education and by the MSIT (RS-2025-00513909).

References

[1] Eggers, B.; Wagenheim, A. M.; Jung, S.; Kleinheinz, J.; Nokhbehsaim, M.; Kramer, F. J.; Sielker, S. Effect of Cold Atmospheric Plasma (CAP) on Osteogenic Differentiation Potential of Human Osteoblasts. Int. J. Mol. Sci. 2022, 23 (5), 2503.

[2] Marques-Carvalho, A.; Kim, H. N.; Almeida, M. The role of reactive oxygen species in bone cell physiology and pathophysiology. Bone Rep. 2023, 19, 101664.

[3] Acharya, T. R.; Lamichhane, P.; Jaiswal, A.; Amsalu, K.; Hong, Y. J.; Kaushik, N.; Kaushik, N. K.; Choi, E. H. The potential of multicylindrical dielectric barrier discharge plasma for diesel-contaminated soil remediation and biocompatibility assessment. Environ. Res. 2024, 240 (Pt 2), 117398.

Invited Lecture

Sasang Constitution as a Stratification Variable for Inter-Individual Variance in Nitric Oxide Response: Toward Convergence with Plasma-Generated NO Water

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Plasma-generated nitric oxide (NO) water is emerging as a powerful and broadly applicable physiological mediator. We raise one further question: why does the response to the same NO differ between individuals? We propose Sasang constitution — a Korean typological framework that stratifies individuals by relative visceral function — as a candidate answer, and present a literature review supporting three hypotheses.

H1. Korean traditional fermented materials are intrinsically rich in NO metabolites. Fermented lettuce extract accumulated nitrite from non-detectable at day 0 to 1,127.41 μg/mL at day 21; fermented garlic extract released 8.9 mol NO per tablet over 24 h in simulated gastric fluid versus 0.1 mol over < 6 h for a reference supplement, and a single oral dose lowered systolic and diastolic blood pressure by 16.93 and 12.34 mmHg ($p = 0.001$, $n = 58$, double-blind, placebo-controlled).

H2. Response variance arises from the synergy rate between the NO-generating substrate and constitution. Constitution is an independent risk factor for metabolic syndrome (propensity-matched OR = 2.01, 95% CI 1.25–3.25; 14-year cohort HR = 1.96, 95% CI 1.41–2.73), and the direction of risk reverses across organ systems (Taeeumin: obesity 62.9%; Soeumin: COPD 30.3%, functional dyspepsia OR = 3.13). Constitutional effect signals amplify systematically with stratification purity (1.3% → 38.9% → 48.1%).

H3. Water-based NO transfers no substrate thermal character and should therefore act as a universal vehicle, yet residual individual variance will persist. Notably, of 41 flower teas assessed by constitution, two were suitable for all four types and none was unsuitable for all four — universal and constitutional terms coexist.

We formalize this as $\Delta E = \alpha\cdot[NO]\_{eff} + \beta\cdot S(c,s)\cdot[NO]\_{eff} + \varepsilon$, define a Constitution–NO Synergy Index, propose a thermal–NO–constitution amplification

model, and specify two falsifiable propositions with a three-phase clinical roadmap. We invite collaboration on constitution-stratified cardiovascular prevention research.

Keywords: Sasang constitution; nitric oxide water; plasma-activated water; stratified trial; cardiovascular prevention

Invited Lecture

Epigenetic Reprogramming by Curcumin in Cancer: Emerging Opportunities for Precision Oncology and Translational Therapeutics

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Breast cancer development involves significant epigenetic dysregulation, making epigenetic therapy a promising avenue for reactivating silenced tumor suppressor genes. This study investigated the therapeutic potential of curcumin, a natural polyphenol, as an epigenetic modulator in MCF-7 breast adenocarcinoma cells, with a focus on the 10 μM concentration. Treatment with 10 μM curcumin effectively inhibited cell proliferation, induced apoptosis, and suppressed colony formation. Mechanistic analysis revealed that curcumin functioned as a dual epigenetic inhibitor, reducing the enzymatic activity of both DNA methyltransferases (DNMTs) and histone deacetylases (HDACs). This action led to promoter hypomethylation and histone hyperacetylation at critical epigenetically silenced loci, including the tumor suppressor genes HIC1 and p16, as well as the detoxification gene GSTP1. Consequently, the mRNA and protein expression of these genes were significantly restored. These epigenetic changes were associated with the downregulation of oncogenic signaling pathways, such as NF-κB and Akt. The findings demonstrate that a physiologically attainable concentration of curcumin (10 μM) exerts potent anti-cancer effects in vitro through coordinated epigenetic reprogramming, highlighting its potential as a safe and effective agent in breast cancer chemoprevention and combination therapy strategies.

Keywords: Breast cancer; Curcumin; Epigenetic therapy; DNA methylation; Histone acetylation; Chemoprevention;

Invited Lecture

Proteomic insights into the rice responses to Magnaporthe oryzae

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Rice blast, caused by *Magnaporthe oryzae*, remains a major constraint to global rice production, necessitating a deeper understanding of host innate immunity for sustainable disease control. MSP1, a secreted protein of *M. oryzae*, was functionally characterized to elucidate its role in rice immune activation. Recombinant MSP1, heterologously expressed in *Escherichia coli*, elicited canonical immune responses, including rapid reactive oxygen species (ROS) burst, callose deposition, autophagic cell death, and induction of pathogenesis-related (PR) genes. Integrated label-free and tandem mass tag (TMT)-based quantitative proteomics of MSP1-treated and MSP1-overexpressing rice plants revealed extensive reprogramming of proteins associated with proteolysis, jasmonate biosynthesis, redox homeostasis, and mitogen-activated protein kinase (MAPK) signaling. Complementary phosphoproteomic analysis identified dynamic phosphorylation of key immune regulators, highlighting post-translational regulation during MSP1-mediated defense. Plasma membrane proteomics further identified candidate MSP1 receptors, with MRH1 emerging as a putative recognition receptor mediating MSP1 perception. Collectively, these findings establish MSP1 as a pathogen-associated molecular pattern (PAMP) that activates PAMP-triggered immunity (PTI) through MRH1-dependent immune signaling. Beyond elucidating a fundamental mechanism of rice immunity, this work provides a molecular foundation for integrating plasma-based technologies, including non-thermal plasma and plasma-activated water, as complementary strategies to potentiate PTI and suppress rice blast through simultaneous pathogen inactivation and immune priming. Such synergistic approaches offer a promising avenue toward sustainable, fungicide-independent management of rice blast disease.

This research was funded by the National Research Foundation of Korea (NRF), funded by the Ministry of Education, Science, and Technology, grant number RS-2026-25492629.

Invited Lecture

Nonthermal Plasma-Mediated Transcriptional Rewiring for Breast Cancer Therapy

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Breast cancer (BC) progression is driven by dynamic transcriptional networks that regulate tumor growth, cellular plasticity, metastasis, and interactions with the tumor microenvironment (TME). Central to these processes are transcription factors (TFs), which orchestrate oncogenic gene expression programs and represent attractive therapeutic targets. Emerging evidence suggests that nonthermal plasma (NTP) exerts potent anticancer effects through the generation of reactive oxygen and nitrogen species (RONS), enabling modulation of multiple cancer-associated signaling pathways. In this study, we explore the potential of nonthermal plasma-mediated transcriptional rewiring as a novel therapeutic strategy for breast cancer. Specifically, we investigate the effects of nonthermal plasma-derived nitric oxide water (NOW) on oncogenic TFs and the signaling networks that govern breast cancer progression. The nitric oxide-rich microenvironment generated by NOW reprograms transcriptional circuits by suppressing key TF activities and disrupting pathways associated with epithelial–mesenchymal transition, metastasis, proliferation, survival, and immune regulation. These coordinated molecular changes influence both tumor cell-intrinsic signaling and the TME, highlighting the multifaceted therapeutic potential of plasma-derived NO. Collectively, this study provides mechanistic insights into the capacity of nonthermal plasma to rewire oncogenic transcriptional networks and reshape the breast cancer transcriptomic landscape. By integrating transcriptional regulation with redox-mediated signaling, our findings establish nonthermal plasma-derived NOW as a promising, noninvasive adjunctive strategy for precision breast cancer therapy and offer a foundation for the development of next-generation plasma-based oncotherapeutics.

This study was supported by the National Research Foundation (NRF) of Korea, funded by the Korean government (RS-2025-16071518, RS-2021-NR060112).

References

[1] Y. Zhao, N. Kaushik, J.H. Kang, N.K. Kaushik, S.H. Son, N. Uddin, M.J. Kim, C.G. Kim, S.J. Lee, *Cancer Research*, 80, 2217–2229 (2020).

[2] A. Jaiswal, M. Negi, E. H. Choi, N. K. Kaushik, N. Kaushik, N, 307, 141915 (2025).

[3] B.D. Lehmann, J.A. Bauer, X. Chen, M.E. Sanders, A.B. Chakravarthy, Y. Shyr, J.A. Pietenpol, 121, 2750–2767 (2011).

[4] N.K. Kaushik, P. Bhartiya, N. Kaushik, Y. Shin, L.N. Nguyen, J.S. Park, D. Kim, E.H. Choi, 19, 569–580 (2023).

Invited Lecture

Plasma-Activated NO Water (PNOW) for Sterilization and Growth Support in Hydroponic Cultivation

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Closed-loop hydroponic systems require chemical-free sterilization strategies that leave no residues and minimize environmental discharge. This study evaluated plasma-activated NO water (PNOW), generated by a multi-cylindrical dielectric barrier discharge (MC-DBD) source, for its microbial inactivation efficacy, minimum inhibitory concentration (MIC), and physiological effect on sprout cultivation.

Antimicrobial activity was tested against Escherichia coli (5×10^4 CFU/mL) and Staphylococcus aureus (5×10^5 CFU/mL) using 20 ppm PNOW. Sterilization performance under realistic conditions was assessed on native microbiota in hydroponic wastewater treated with either 0.2 ppm or 0.5 ppm PNOW. MIC was determined by two-fold serial dilution followed by OD600 monitoring. Sprout bioactivity, including Total Phenolic, Total Flavonoid, DPPH radical scavenging, and FRAP, was compared between the 0.2 ppm and 0.5 ppm treatment groups across seven crop species.

Complete inactivation was achieved within 20 min for E. coli (>4 log reduction) and within 5 min for S. aureus (≥5.7 log reduction). In real hydroponic wastewater, 81-96% reduction was observed at 0.2-0.5 ppm. MIC was 0.25 ppm for both strains. Antioxidant indices in sprouts were largely preserved in the 0.2 ppm group, while Broccoli and Mung Bean showed additional gains at 0.5 ppm.

PNOW generated by the MC-DBD source provides effective sterilization from ideal to realistic hydroponic conditions and supports sprout physiology across a range of low-concentration treatments. These findings suggest that PNOW is a promising candidate for residue-free water management in sustainable agriculture.

Keywords *Plasma-activated NO water, MC-DBD, hydroponic sterilization, MIC, sprout antioxidants, sustainable agriculture*

Acknowledgement *Jeonbuk State Agricultural Research and Extension Services, titled Development of Plasma-Based Circulating Nutrient Solution Sterilization Technology for Paprika (Project No.: LP005296022025)*

Invited Lecture

Multi-cylinder dielectric barrier discharge plasma-generated reactive species for sustainable viral, bacterial, and fungal inactivation

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The increasing prevalence of viral, bacterial, and fungal pathogens in the health, agriculture, and aquaculture sectors underscores the need for eco-friendly and chemical-free disinfection technologies. In this study, a multi-cylinder dielectric barrier discharge (MCDBD) plasma system was employed to generate reactive oxygen and nitrogen species (RONS) such as nitrogen oxides (NO_x), ozone (O_3), and plasma-activated water (PAW) with the aim of controlling a wide range of pathogens. The antiviral efficacy of the plasma platform against human coronavirus-229E (HCoV-229E) was evaluated using direct plasma exposure, PAW, and PAW-treated cotton fabric. Plasma treatment reduced the viral infectivity by 3.5–4.0 log $TCID_{50}$/mL and suppressed the expression of the viral envelope and envelope proteins; furthermore, it significantly reduced the levels of the spike glycoprotein. These results confirm the capability of this plasma technology to effectively disinfect reusable hospital personal protective equipment (PPE). The antifungal efficacy against the fungal pathogens *Colletotrichum acutatum* and *Colletotrichum gloeosporioides* was evaluated. The study results revealed that RONS generated by plasma effectively inactivated both pathogens under both in vitro and in vivo conditions. Furthermore, PAW-NO_x not only effectively controlled fungal infection but also better preserved the biochemical quality of the strawberry fruits and plants compared to PAW-O_3. The antibacterial efficacy of PAW was further evaluated against *Aeromonas hydrophila*, *Escherichia coli*, and *Staphylococcus aureus*. PAW achieved a reduction of approximately 3 log CFU/mL in planktonic bacteria, effectively disrupted pre-formed biofilms, and induced damage to the bacterial membrane through oxidative and nitrosative stress. Overall, these findings suggest that the RONS generated by MCDBD plasma, they highlight the provision of a versatile, scalable, and eco-friendly

platform for inactivating a wide range of pathogens across the health, agriculture, and aquaculture sectors, serving as a promising alternative to commonly used chemical disinfectants.

Invited Lecture

TRIM33 Gene down regulation and Promoter Methylation Exhibits Significant Correlation with Clinical Parameters in Indian Breast Cancer Patients

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Abstract

Breast cancer continues to be a major source of cancer-related morbidity and mortality among women despite significant advancements in detection and treatment. This is mostly because of recurrence, metastasis, and therapeutic resistance [1]. With functions in cell proliferation, invasion, migration, and metastasis, members of the tripartite motif-containing protein family have emerged as significant regulators of tumor growth. Due in part to its participation in TGF-β-related signaling pathways, TRIM33 has been shown to operate context-dependently as either a tumor suppressor or a tumor promoter in various cancers [2-3]. However, little is known about the expression pattern and epigenetic regulation of TRIM33 in breast cancer, especially in Indian patients. At the time of surgery, 52 patients with sporadic breast cancer had their breast tumor tissues and nearby normal tissues examined for TRIM33 expression and promoter methylation status. Western blotting, immunohistochemistry, and quantitative real-time PCR were used to measure TRIM33 mRNA and protein expression. Methylation-specific PCR was used to assess the methylation status of the promoter. We looked at relationships between TRIM33 expression, promoter methylation, and clinicopathological characteristics, such as TNM stage. When compared to nearby normal tissues, TRIM33 expression was lower in breast carcinoma tissues. Reduced TRIM33 expression was linked to TRIM33 promoter methylation, indicating that epigenetic silencing may play a role in the down regulation of TRIM33 in breast cancer. Higher illness stage and other advanced clinicopathological characteristics were significantly correlated with decreased TRIM33 expression and promoter methylation ($p = 0.04$).These results imply that TRIM33 down regulation, which may be mediated by promoter methylation, may be a significant factor in the development of breast cancer and may be a possible predictive biomarker for patients with breast cancer in India.

Keywords: Breast cancer; TRIM33; promoter methylation; epigenetic regulation; TGF-β; cancer biomarker

Acknowledgment

The Indian Council of Medical Research grant (IIRP-2023-2456/F1) to Dr. Md. Margoob Ahmad provides financial support to the author's lab. Author’s laboratory is also supported by Bihar Council of Scientific Technology (BCST-RD-01/2022-799).

References

Feng, Yixiao et al. “Breast cancer development and progression: Risk factors, cancer stem cells, signaling pathways, genomics, and molecular pathogenesis.” *Genes & diseases* vol. 5,2 77-106. 12 May. 2018, doi:10.1016/j.gendis.2018.05.001

Batra, R.N., Lifshitz, A., Vidakovic, A.T. *et al.* DNA methylation landscapes of 1538 breast cancers reveal a replication-linked clock, epigenomic instability and *cis*-regulation. *Nat Commun* **12**, 5406 (2021). https://doi.org/10.1038/s41467-021-25661-w

Eickhoff, N., Janetzko, J., Padrão, N. *et al.* TRIM33 loss reduces androgen receptor transcriptional output and H2BK120 ubiquitination. *Commun Biol* **8**, 1043 (2025). https://doi.org/10.1038/s42003-025-08449-2

Invited Lecture

Low-Temperature Plasma-Driven Molecular Transformation of Natural Products for Biomedical Applications

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Low-temperature plasma produces chemically active species through non-equilibrium processes, providing a distinct reaction environment for plasma–liquid chemistry. This study examines plasma-driven molecular transformation of natural products with a focus on reaction mechanisms governed by plasma-generated species. Phenolic compounds and steroid-based molecules were used as model substrates to analyze plasma-induced reactions in liquid systems. Plasma exposure induced oxidation, hydroxylation, and dimerization reactions that differ from conventional solution-phase chemistry. In particular, epigallocatechin gallate (EGCG) underwent controlled dimerization through methylene-bridge formation. To clarify dominant plasma-chemical pathways, molecular transformations arising from direct plasma interaction were distinguished from indirect reactions mediated by long-lived reactive oxygen and nitrogen species (RONS). The influence of plasma parameters, including applied voltage and treatment time, was systematically evaluated to correlate reactive species generation with molecular conversion behavior. The results indicate that ozone-related intermediates and radical-driven reactions play a central role in molecular restructuring in plasma–liquid systems. These findings demonstrate that low-temperature plasma can serve as a chemically controllable reaction platform for molecular transformation of natural products.

This work was supported by National Grant no. This work was supported by the R&D Program entitled " Plasma Bio Convergence Technology Research Project (EN2625-13)" through the Korea Institute of Fusion Energy (KFE), funded by the government of the Republic of Korea.

References

[1] G.H. Jeong, et. al., *J. Phys. D: Appl. Phys.,* 53 (2020) 274005.
[2] S. Park, et. al., *Scientific Reports*, 12, 15396 (2022).
[3] S.H. Ki, et. al., *Scientific Reports*, 14, 19749 (2024).

Invited Lecture

From Plasma to Petals: Improving Flower Shelf Life with Plasma Activated Water

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Flowers of Night-Blooming Jasmine (*Cestrum nocturnum* L.) are highly delicate and spoil quickly after harvest, limiting their commercial and ornamental value. In this study, we explored the use of plasma-activated water (PAW) as a novel and eco-friendly approach to extend their shelf life.

PAW is water treated with plasma, which enriches it with reactive species that can modify its chemical properties. We prepared PAW with different treatment times and used it either to wash the flowers or as a storage medium. Plasma treatment made the water more acidic and increased its oxidation strength, along with beneficial reactive compounds such as nitrates and peroxides, etc. [1]

Our results show that using PAW as a washing treatment significantly improved flower quality during storage. It reduced microbial growth, slowed spoilage, minimized weight loss, and helped maintain color and freshness. Even after 15 days, flowers treated with PAW showed lower microbial activity and better overall quality compared to untreated samples. In addition, PAW-treated flowers retained brighter appearance and antioxidant properties for a longer time [1].

However, when PAW was used directly as a storage medium, it was less effective and could even cause damage due to prolonged exposure to reactive species [1]. Overall, this study demonstrates that plasma-activated water is a promising, sustainable technology for postharvest preservation of flowers when used as a washing treatment, though careful optimization is needed for storage applications.

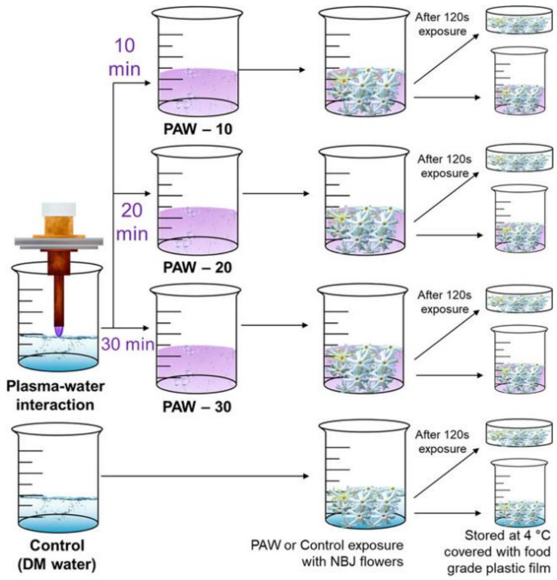

Fig. 1. Preparation of PAW and its use for washing and storing night-blooming jasmine flowers [1].

References

[1] V. Rathore and S. K. Nema *New Zealand Journal of Crop and Horticultural Science*, 54, e70155 (2026). https://doi.org/10.1002/nzc2.70155

INDUSTRY SESSIONS

Industry Session

Introduction to PLASADE Co., LTD

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Our company specializes in the research and development of plasma-based eco-friendly agricultural technologies, driving sustainable innovation through advanced plasma bioscience. By utilizing plasma-generated reactive species and their precise control, we develop innovative agricultural solutions that promote crop growth, suppress plant diseases, and create environmentally sustainable farming systems. Our goal is to realize sustainable agriculture by minimizing the use of chemical agents while enhancing agricultural productivity and environmental safety.

Building upon our expertise in plasma bioscience, we possess the capability to develop and manufacture plasma-based equipment for applications in public health, environmental sanitation, and human well-being. Our technologies provide safe, efficient, and environmentally friendly solutions that extend beyond agriculture into diverse environmental and biomedical fields, contributing to the broader industrial adoption of plasma technology.

The company has secured proprietary core technologies and a strong portfolio of patents, establishing an independent technological foundation without reliance on third-party technologies. Leveraging our patented innovations, we deliver differentiated plasma technologies and high-value products tailored to the environmental, agricultural, and biotechnology sectors. Through continuous technological advancement and commercialization, we are committed to leading the future of sustainable plasma applications and contributing to the development of next-generation eco-friendly industries.

Industry Session

Introduction to BIO PLATECH Co., Ltd.

Dae Kyu Joo

BIO PLATECH Co., Ltd., Seoul, Republic of Korea

BIO PLATECH Co., Ltd., led by CEO Dae-gyu Joo, is a Korean research-driven company specializing in plasma technology for healthcare, environmental, and industrial applications. In collaboration with the Plasma Bioscience Research Center (PBRC) at Kwangwoon University, the company develops and manufactures innovative plasma-based medical devices, air sterilization systems, and environmental solutions. BIO PLATECH has obtained GMP certification for medical device manufacturing and operates a certified corporate research institute. Its key achievements include the commercialization of the Plasma Cure Air sterilizer with proven 99.9% coronavirus removal performance, participation in government-funded R&D projects, and the development of advanced monitoring and odor-removal technologies for public and industrial applications.

Industry Session

Introduction to DAWOO Korea Co., Ltd.

Joon Hyung Bae

DAWOO Korea Co., Ltd., Republic of Korea

DAWOO Korea, led by CEO Jun-hyung Bae, is a Korean technology company specializing in the development and manufacturing of advanced plasma-based air sterilization systems. Utilizing its proprietary high-density plasma technology, the company provides innovative solutions for reducing airborne pollutants, bacteria, and viruses, creating safer and healthier indoor environments across hospitals, ambulances, public facilities, commercial buildings, and residential spaces. Developed in collaboration with the Plasma Bioscience Research Center (PBRC), Kwangwoon University, DAWOO Korea's plasma sterilization technology has received broad recognition for its innovation and performance. Through continuous innovation and quality excellence, DAWOO Korea is committed to advancing next-generation plasma technologies for healthier living environments.

Industry Session

Introduction to ColdPla Co., Ltd.

Misun Lee

ColdPla Co., Ltd., Republic of Korea

ColdPla Co., Ltd., under the leadership of CEO Mi-seon Lee, is a Korean innovator in cold plasma-based solutions for beauty, wellness, and personal healthcare. Integrating cutting-edge plasma technology with intuitive product design, the company delivers advanced devices for skin care, hygiene, and home healthcare applications. Driven by technological excellence, ColdPla is committed to providing safe, effective, and scientifically proven solutions that support healthier lifestyles. Through ongoing research and development, continuous product innovation, and a customer-centric approach, the company continues to strengthen its competitive edge in the global market. Building on its proprietary patented technologies, ColdPla is now ambitiously expanding its reach into the medical industry.

POSTER PRESENTATIONS

Poster Presentation

Exploring Plasma Activated NO Water for Stress Mitigation, Muscle Health and Aging

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Aging and chronic stress accelerate functional decline in skeletal muscle by disrupting redox and inflammatory homeostasis, driving a state of inflammaging that impairs tissue repair and regeneration. Nonthermal plasma (NTP) and its nitric oxide enriched derivatives offer promising approaches to modulate cellular redox signalling and counteract aging associated dysfunction. In this study, we investigate the effects of plasma activated nitric oxide (NO) on molecular pathways linking oxidative stress, inflammation, and muscle senescence. Using cultured skeletal muscle cells, we assess how NTP derived NO influences transcriptional regulators associated with stress adaptation, mitochondrial function, and inflammatory signalling. The expected outcomes include restoration of beneficial NO signalling, attenuation of inflammation driven aging markers, and reinforcement of muscle homeostasis. Collectively, this work positions plasma activated NO as a potential therapeutic mediator for mitigating inflammaging and promoting cellular resilience in muscle related aging and stress conditions.

This study was supported by the National Research Foundation (NRF) of Korea, funded by the Korean government (RS-2021-NR060112).

References

[1] A. Jaiswal, N. Kaushik, E.H. Choi, H. Uhm, and N.K. Kaushik, *ACS Applied Materials & Interfaces*, 16, 56348 (2024).

[2] J.W. Choi, S.U. Kang, Y.E. Kim, J.K. Park, S.S. Yang, Y.S. Kim, Y.S. Lee, Y. Lee, and C.-H. Kim, *Bioengineering*, 10, 1047 (2023).

[3] L.R. Polsky, K.E. Rentscher, and J.E. Carroll, *Psychoneuroendocrinology*, 158, 106389 (2023).

[4] C. Liu, D. Zheng, R. Zhang, H. Li, X. Tong, Y. Wu, G. Zhang, S. Wang, H. Chen, Z. Ren, Y. Sun, C. Wang, D. Li, X. Li, M. Li, and L. Jin, *Aging Cell*, 22, e13974 (2023).

Poster Presentation

Plasma-Generated Nitric Oxide Water as an Antiviral Strategy Against Vaccinia Virus

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Poxviruses are environmentally stable DNA viruses that predominantly initiate infection through the skin, leading to localized lesions, rashes, and cutaneous inflammation. Vaccinia virus (VACV), a well-established surrogate for emerging poxviruses, provides a relevant model for evaluating antiviral intervention strategies targeting skin-associated infections. In this study, we present an eco-friendly plasma-based approach for VACV inactivation using nitric oxide plasma activated water (NO-PAW), with a focus on skin-relevant infection models.

NO-PAW was generated using a non-thermal plasma system optimized for controlled nitric oxide species production and applied to VACV prior to host exposure. Viral infectivity, cytocompatibility, and host-virus interactions were systematically evaluated using fluorescence-based infection assays and cellular viability analyses. The results demonstrate that plasma-generated NO water effectively reduces VACV infectivity while maintaining high biocompatibility with skin-associated host cells. The observed antiviral activity is attributed to plasma-derived reactive nitrogen species that induce physicochemical modifications in viral surface proteins, thereby impairing viral attachment and early- stage infection processes. Emphasis on skin-relevant models underscores the translational potential of this strategy for topical antiviral applications.

Overall, this work highlights nitric oxide plasma activated water as a sustainable, non-toxic, and effective antiviral platform for poxvirus inactivation at the skin interface. These findings support the broader applicability of plasma-generated NO systems for controlling environmentally persistent viruses and advancing plasma-based solutions for dermatological viral management, wound-associated infections, and outbreak preparedness.

References

P. Patel, T.R. Acharya, S.S. Lenka, S. Ghosh, S. Mukherjee, P. Lamichhane, A. Jaiswal, S.K. Verma, N. Kaushik, E.H. Choi, Inactivation of Vaccinia Virus via Nitric Oxide-Plasma Activated Water: A Potential Way to Inactivate Mpox Virus, *J. Hazard. Mater.* 499 (2025) 139961.

P. Patel, N. Kaushik, T.R. Acharya, E.H. Choi, N.K. Kaushik, Surface air gas discharge plasma: An ecofriendly virus inactivation approach to enhance CPRRs mediated antiviral genes expression against airborne bio-contaminant (human Coronavirus-229E), *Environ. Pollut.* 347 (2024) 123805.

N.K. Kaushik, S. Mondal, E.J. Bak, L.N. Nguyen, P. Bhartiya, J.H. Kim, E.H. Choi, The inactivation and destruction of viruses by reactive oxygen species generated through physical and cold atmospheric plasma techniques: Current status and perspectives, *J. Adv. Res.* 43 (2023) 59–71.

N.K. Kaushik, P. Bhartiya, N. Kaushik, Y. Shin, L.N. Nguyen, J.S. Park, D. Kim, E.H. Choi, Nitric-oxide enriched plasma-activated water inactivates 229E coronavirus and alters antiviral response genes in human lung host cells, *Bioact. Mater.* 19 (2023) 569–580.

Poster Presentation

Mapping nitrosative hotspots in coronavirus spike glycoproteins for virus inactivation

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The SARS-CoV-2 spike glycoprotein mediates host-cell entry through receptor recognition and membrane fusion and has diversified across variants and related coronaviruses. Although spike mutations have been extensively characterized structurally and phylogenetically, their effect on predicted susceptibility to reactive nitrogen species remains poorly quantified. This is relevant to nitric oxide-derived species generated in plasma-activated water, which may contribute to antiviral activity through chemical modification of viral proteins. We performed a comparative bioinformatics analysis of full-length spike glycoproteins from representative human and zoonotic coronaviruses using sequences retrieved from the NCBI Virus database. Multiple sequence alignment, maximum-likelihood phylogenetic reconstruction, mutation frequency, Shannon entropy, and domain-level annotation were used to map sequence variability across spike functional regions. Predicted nitrosative susceptibility was quantified by integrating reactive residue composition, nitrosation-prone residue enrichment, domain localization, sequence variability, and structural exposure. Mutation burden and entropy were concentrated in the NTD, RBD/RBM, and S1/S2 cleavage region. Omicron BA.2 showed redistribution of predicted nitrosative susceptibility within the RBD/RBM interface. RBD-ACE2 docking showed comparable predicted binding for Wuhan-Hu-1 and Alpha, whereas Omicron BA.2 displayed a less favorable HADDOCK score. These findings identify the RBD/RBM interface as a mutation-enriched, ACE2-contacting, chemically reactive region for experimental validation of reactive nitrogen species and plasma-activated water-mediated spike modification.

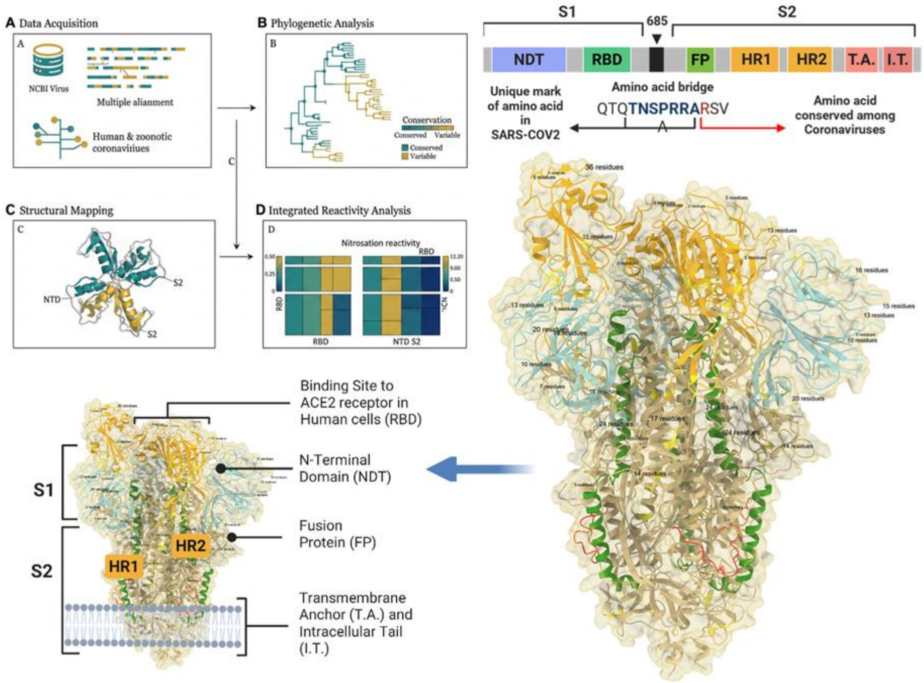

Fig. 1. Computational workflow and domain organization of coronavirus spike proteins. (A) Overview of the comparative bioinformatics workflow used for sequence retrieval, phylogenetic analysis, nitrosation site prediction, structural annotation, and evolutionary comparison of coronavirus spike proteins. (B) Schematic representation of the spike glycoprotein showing major functional domains, conserved cysteine-rich regions, and representative nitrosation-prone residues analyzed in this study.

References

P. Patel, N. Kaushik, T. R. Acharya, S. S. Lenka, S. Ghosh, R. Wahab, S. K. Verma, E. H. Choi, N. K. Kaushik, Inactivation of Pseudovirus Expressing the D614G Spike Protein Mutation using Nitric Oxide-Plasma Activated Water. *Adv. Sci.* 2024, 11, 2411515.

J. Geng, L. Chen, Y. Yuan, *et al.* CD147 antibody specifically and effectively inhibits infection and cytokine storm of SARS-CoV-2 and its variants delta, alpha, beta, and gamma. *Sig Transduct Target Ther* 6, 347 (2021).

Ck. Oh, T. Nakamura, N. Beutler, *et al.* Targeted protein S-nitrosylation of ACE2 inhibits SARS-CoV-2 infection. *Nat Chem Biol* 19, 275–283 (2023).

Poster Presentation

Surface Modification of β -Tricalcium Phosphate Scaffold by Hydration with Plasma-Activated Solutions

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Bone graft materials are widely used for bone tissue regeneration in dentistry and orthopedics. However, ceramic-based bone graft materials, such as β-tricalcium phosphate (β-TCP), exhibit limited osteoinduction despite their excellent osteocondution. Although direct plasma treatment has been researched to enhance the biological performance of graft materials, its clinical application remains limited due to challenges associated with sterilization and storage. Plasma-activated solutions offer a practical approach to overcoming these limitations by indirectly delivering the effects of plasma treatment. Therefore, this study aims to evaluate the potential of plasma-activated water (PAW) and plasma-activated saline (PAS) as multifunctional hydration solutions capable of replacing conventional clinical hydration media.

β-TCP scaffold was fabricated by freeze-casting using a slurry compose of hydroxyapatite (HA), distilled water (DW), and gelatin. The crystallinity of the scaffolds was evaluated by X-ray diffraction (XRD), while their surface and cross-sectional morphologies were characterized using scanning electron microscopy (SEM). Porosity and pore size were analyzed by porosimeter. The PAW and PAS was prepared by treating distilled water (DW) and saline with plasma-generated NO gas in a ME-DBD system with anambient air flow of 2.0 L/min for 20 min in an open system. The scaffolds were hydrated for 30 min in PAW and PAS containing nitric oxide (NO) at concentrations of 0, 40, 200, 1000, and 5000 μM. Changes in the surface chemical composition were then analyzed using X-ray photoelectron spectroscopy (XPS). Finally, initial cytotoxicity was evaluated using a CCK-8 assay with murine MC3T3-E1 pre-osteoblast cells.

XRD analysis showed that the diffraction pattern of the fabricated β-TCP scaffold was consistent with the standard JCPDS card (09-0169). SEM images revealed that stable inter-particle bonding and formation of a porous structure. The pore size distribution was primarily within the range of 20-50 µm, with an average porosity of 51.55 ± 2.01%. XPS analysis showed that increasing NO concentrations in PAW and PAS increased the surface nitrogen content from 0 to 1.27% and from 0 to 0.83%, respectively, while the N/P ratio increased from 0 to 0.11 and from 0 to 0.08. Furthermore, deconvolution of the N1s peak confirmed the adsorption of nitrate and nitrite species onto the scaffold surface.

In conclusion, hydration of β-TCP scaffolds with PAW and PAS modified the surface chemical composition while maintaining the structural integrity and biological safety of the scaffold. These findings suggest the potential of PAW and PAS as a next-generation hydration solution for bone graft materials. Future studies will investigate its osteogenic effects and underlying mechanisms, as well as its antibacterial effects.

Poster Presentation

Analysis for the growth of bok-choy (Brassica rapa subsp. chinensis) in plasma-applied hydroponic culture

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Currently, climate change is a major issue in agriculture leading to the reduction of crop yields and economic losses. Many studies in agriculture have explored the potential of non-thermal plasma to enhance plant growth, seed germination, and plant defense. Additionally, a hydroponic system is an alternative agriculture production method that requires less space. Integrating non-thermal plasma technology with hydroponic systems presents an alternative and promising technology for enhancing crop production in the current environmental conditions [1,2]. Our study investigates multiple-cylinder DBD plasma (4 pairs of electrodes) to generate nitric oxide in a hydroponic system for cultivation of bok choy (*Brassica rapa* subsp. *chinensis*). Nutrient solution (1X of Hoagland solution) was treated using multiple-cylinder DBD plasma for plasma-gas treatment (10 s, 30 s, and 60 s) or none (0s) every week. At 35 days, we observed significantly elevated bok choy growth (shoot length, root length, and dry biomass) in culture using plasma-gas-treated Hoagland solution for 10 and 30 seconds. Also, nitrate assimilation as nitrate and (NO_3^--N) and ammonium (NH_4^+-N) ions in plant tissue increased in plasma-gas treatment compared with the control. Measurements of the Hoagland solution's pH, oxidation-reduction potential (ORP), and electrical conductivity (EC) revealed no changes during plasma-gas treatment. While hydrogen peroxide levels were marginally higher than in the control, nitrate levels were much higher in the plasma-gas treatment (10s, and 60s). Research on plant molecular changes and their effects on microbial and algal decontamination in hydroponic systems is still ongoing.

This work was supported by the National Research Foundation of Korea (NRF) (RS-2021-NR060112, 2020R1F1A1070942) and Korea Agriculture Technology Promotion Agency (KOAT).

References

[1] Sodini, M., Traversari, S., Cacini, S., Gonfiotti, I., Lenzi, A., Massa, D., Front. Plant Sci., 15, 1511335, (2024).

[2] Veerana, M., Ketya, W., Choi, E.H., Park, G., Front. Plant Sci., 15,1445791, (2024).

Poster Presentation

Spent granular activated carbon regeneration using peroxydisulfate in Dielectric Barrier Discharge system

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This study investigated the synergistic regeneration of volatile organic compound (VOC) loaded spent granular activated carbon (wGAC) using air-purging dielectric barrier discharge (DBD) combined with peroxydisulfate (PDS) system. In the closed-loop circulation, plasma-only achieved up to 40% regeneration efficiency. The addition of PDS significantly enhanced the wGAC regeneration performance, with an optimal PDS/wGAC ratio of 0.071 mmol g^{-1} yielding 81% regeneration (phenol tracer), approximately twice that of plasma alone. Electron spin resonance (ESR) confirmed $SO_4^{\bullet-}$ and •OH generation, revealing the synergistic reactive oxygen species (ROS) formation in the plasma-PDS system. Characterization of regenerated GAC (rGAC) using N_2 adsorption–desorption and FE-SEM analysis was conducted. Plasma-PDS achieved up to 96% micropore volume recovery relative to new GAC (nGAC), outperforming other reported regeneration methods. Process water recycling for four consecutive cycles maintained a stable 74% regeneration efficiency. The enhanced regeneration was attributed to the longer-lived $SO_4^{\bullet-}$, produced via the reaction between $^1O_2$ and PDS, enabled micropore regeneration.

This work was supported by National Research Foundation of Korea (NRF) (Grant No. RS-2026-25472979 and RS-2021-NR060112).

References

[1]. Li, Ning, et al., Thermal activation of persulfates for organic wastewater purification: Heating modes, mechanism and influencing factors, *Chemical Engineering Journal,* 450, 137976 (2022).

[2] Dong Yoon Oh, Kien Tiek Wong, Seok Byum Jang, Jun Sup Lim, Junghyun Lim, Choe Earn Choong, Yeomin Yoon, Eun Ha Choi, Min Jang, Dielectric barrier discharge plasma combined with peroxydisulfate for efficient regeneration of waste granular activated carbon: Enhancing micropore recovery, *Chemical Engineering Journal*, 519,165363 (2025).

Poster Presentation

Non-Thermal plasma induced degradation of methyl paraben: Role of hydroxyl radicals and toxicity mitigation

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Methylparaben (MP), a widely used antimicrobial preservative, has emerged as a contaminant of concern in aquatic environments and existing systems for MP degradation have limitations, such as requiring strict pH control, iron addition and relatively long treatment times. In this study, we addressed these issues by developing and evaluating a multi-electrode cylindrical dielectric barrier discharge (MEC-DBD) non-thermal plasma system for MP degradation in water. We investigated the MEC-DBD plasma process by evaluating the MP removal, mineralization efficiency, reactive species contribution, plasma characteristics and liquid chromatography–mass spectrometry (LC–MS)-based transformation pathways. Comprehensive electrical and optical characterizations confirmed stable plasma operation and the effective generation of reactive oxidative species during treatment. A reactive species analysis revealed that hydroxyl radicals(•OH) were the dominant oxidizing species and played a primary role in MP degradation. Under optimized conditions, the MEC-DBD system achieved 98% MP degradation in 200 mL of deionized water within 30 min. The influence of initial pH further showed enhanced degradation under acidic conditions, where 97% removal was achieved with an energy yield of 3.11 g kWh^{-1}. LC–MS analysis identified major transformation intermediates, including methyl 2,3,4,5-tetrahydroxybenzoate and supported the proposed degradation pathway for MP oxidation and subsequent breakdown. This study highlights the strong potential of plasma-based treatment for wastewater remediation and environmental protection.

Poster Presentation

Development of Treatment Technology for High-Efficiency PFOA Decomposition Using DBD Plasma–NaOCl Hybrid Advanced Oxidation Process

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Perfluorinated compounds (PFAS) are representative non-biodegradable pollutants that are rarely decomposed in the environment, and in particular, perfluorooctanoic acid (PFOA, C8) is difficult to completely remove and mineralize through conventional biological treatment or adsorption processes alone due to strong carbon-fluorine (C–F) bonds [1, 2]. Recently, the U.S. EPA has set a legal maximum drinking water concentration (MCL) of 4.0 ng/L (ppt) for PFOA and perfluorooctanesulfonic acid (PFOS, C8) [3]. The DBD plasma process has the advantage of being able to activate the stable bonds of PFAS by generating various reactive active species (•OH, O_3, $O_2^{\bullet-}$, e^-, UV, etc.) under room temperature and atmospheric pressure conditions [4], but there are limitations in the efficiency of active species transfer and energy efficiency in water reactions when used as a standalone process [5]. In addition, combining low concentrations of hypochlorous acid (NaOCl) may promote the degradation of PFAS through the formation of reactive chlorine species (RCS). Therefore, this study aims to improve the PFAS degradation efficiency using a DBD plasma–NaOCl hybrid process.

This work was supported by the National Research Foundation of Korea and the Ministry of Science and ICT (RS-2026-25470207), by the National Research Foundation of Korea (NRF) Basic Science Research Program funded by the Ministry of Education (RS-2023-00237769), by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (RS-2021-NR060112), and by the Integrated Environmental Management Specialized Graduate School Program of the Korea Environment Corporation, funded by the Government (Ministry of Climate, Energy and Environment).

References

[1] Ross, I. et al, "A review of emerging technologies for remediation of PFAS”, *Remediation Journal*, 28, 101-126, (2018).

[2] Wang, Z. et al, "A never-ending story of PFAS", *Environmental Science & Technology*, 51(5), 2508-2518, (2017).

[3] U.S. EPA, "Final National Primary Drinking Water Regulation for PFAS", (2024).

[4] Ron, I. et al, " Non-Contact, Continuous Sampling of Porous Surfaces for the Detection of Particulate and Adsorbed Organic Contaminations by Low-Temperature Plasma Coupled to Ion Mobility Spectrometer", *Sensors*, 23(4), 2253, (2023).

[5] Chhakchhuak, V. et al, "Highly efficient removal of PFOA using synergy of cold Plasma, Sulfate Radicals", *Chemical Engineering Journal*, 507, 160334, (2025).

Poster Presentation

Synergy of Nonthermal Plasma and Multifunctional $MnFe_2O_4$/Boron-Doped Graphene Hybrid Catalyst for Efficient Pharmaceutical Wastewater Remediation

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This study presents the integration of a magnetic spinel ferrite $MnFe_2O_4$/boron-doped graphene (B-G) hybrid catalyst with nonthermal plasma as an efficient strategy for advanced wastewater treatment. To the best of our knowledge, this is the first study to design and mechanistically validate $MnFe_2O_4$/B-G as a multifunctional catalytic platform for plasma-driven micropollutant degradation, enabling catalytic ozonation, photo-Fenton-like redox cycling, and plasma-assisted photocatalysis within a single reactor system. The coupling of $MnFe_2O_4$ with B-G enhanced light absorption, promoted charge separation, and improved redox reactivity. In the plasma system, $MnFe_2O_4$/B-G facilitated ozone decomposition and promoted photo-Fenton-like reactions under plasma-induced UV–visible irradiation through Fe^{2+}/Fe^{3+} and $Mn^{2+}/Mn^{3+}/Mn^{4+}$ redox cycling, assisted by the conductive B-G support. In addition, the hybrid catalyst induced plasma-assisted photocatalytic activity, leading to the generation of additional reactive oxygen species (ROS). As a result, the synergistic interaction between nonthermal plasma and $MnFe_2O_4$/B-G markedly enhanced the degradation and mineralization of recalcitrant pharmaceutical pollutants. Comprehensive physicochemical characterization confirmed the successful synthesis of uniformly dispersed $MnFe_2O_4$ nanoparticles on the B-G support, while degradation experiments demonstrated over 88% mineralization within a short treatment period. Radical scavenging tests revealed that hydroxyl radicals and singlet oxygen were the dominant reactive species responsible for pollutant mineralization. Overall, this plasma–catalyst system provides a sustainable and efficient approach for tertiary wastewater treatment by simultaneously improving micropollutant removal and mitigating residual ozone. These findings highlight the potential of multifunctional plasma-catalytic systems for advancing environmental remediation technologies.

This work was supported by the National Research Foundation of Korea and the Ministry of Science and ICT (RS-2026-25470207) and the National Research Foundation of Korea (NRF) Basic Science Research Program (supported by the

Ministry of Education, RS-2023-00237769) and the Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education (RS-2021-NR060112).

Poster Presentation

Space Pathogens: Survival and Virulence in Crewed Space Missions and Plasma-Based Control Strategies

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Crewed spaceflight exposes astronauts to microgravity, galactic cosmic radiation, and immune dysregulation, increasing the risk of infectious diseases during long-duration missions. In the closed environment of the International Space Station (ISS), opportunistic pathogens can accumulate and undergo adaptive changes that enhance virulence and antimicrobial resistance. For example, under Low-Shear Modeled Microgravity (LSMMG), *Salmonella typhimurium* exhibits increased virulence linked to Hfq-mediated transcriptional regulation, while ISS-derived *Enterobacter bugandensis* strains possess expanded antimicrobial resistance genes and mobile genetic elements. These findings indicate that the spaceflight environment acts as a selective pressure for the emergence of hypervirulent and multidrug-resistant pathogens. To address these challenges, plasma-based antimicrobial strategies offer promising non-antibiotic countermeasures. Direct jet plasma can enable localized sterilization of surfaces or wounds, dielectric barrier discharge (DBD) plasma provides efficient surface decontamination of spacecraft materials, and plasma-generated nitric oxide (NO) water can serve as a liquid disinfectant for microbial inactivation and biofilm control. Together, these plasma technologies provide innovative approaches for infection control in future crewed space missions.

References

[1] J. Barrila, J. Yang, K.P. Franco Meléndez, S. Yang, K. Buss, T.J. Davis, B.J. Aronow, H.D. Bean, R.R. Davis, R.J. Forsyth, C.M. Ott, S. Gangaraju, B.Y. Kang, B. Hanratty, S.D. Nydam, E.A. Nauman, W. Kong, J. Steel, and C.A. Nickerson, Frontiers in Cellular and Infection Microbiology, 12, 705647 (2022).

[2] P. Sengupta, S.K. Muthamilselvi Sivabalan, N.K. Singh, K. Raman, and K. Venkateswaran, Microbiome, 12, 62 (2024).

[3] S.K. Mehta, R. Suresh, K. Brandt, D.M. Diak, S.M. Smith, S.R. Zwart, G. Douglas, M. Nelman-Gonzalez, S. Clemett, T. Brunstetter, and B.E. Crucian, Journal of Allergy and Clinical Immunology: Global, 3, 100244 (2024).

[4] I. Irby and J.T. Broddrick, Nature Communications, 15, 3474 (2024).

Poster Presentation

Reactive Species-Driven Degradation of Organic Pollutants Using a Dielectric Barrier Discharge Plasma System

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The removal of persistent organic pollutants such as dyes, antibiotics, and perfluorinated compounds from wastewater remains a significant environmental challenge. In this study, an atmospheric pressure dielectric barrier discharge (DBD) plasma liquid-film reactor was developed to enhance gas–liquid interaction and improve degradation efficiency. Target contaminants included methylene blue (MB), congo red (CR), tetracycline (TC), and perfluorooctanoic acid (PFOA). The liquid-film configuration enables efficient contact between reactive oxygen and nitrogen species (RONS) generated in plasma and aqueous pollutants, offering a promising advanced oxidation process for wastewater treatment. Circulating wastewater as a thin liquid film enhanced degradation efficiency by improving plasma–liquid interaction, while excessively high flow rates reduced performance due to mass transfer limitations. Increasing air flow improved oxygen availability, boosting the generation of hydroxyl radicals (•OH) and ozone (O3). Higher initial pH further enhanced degradation via ozone–hydroxide reactions, although pH decreased during treatment due to nitric acid formation. Scavenger tests showed that reactive species contributed in the order: O3 > 1O2 > O2•− > e− > •OH, indicating ozone-dominated pathways. The system exhibited high energy efficiency, with yields of 0.97 g/kWh for methylene blue (MB), 0.92 g/kWh for Congo red (CR), and 1.01 g/kWh for tetracycline (TC) for 10 mg/L.

Acknowledgements

This work was financially supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (RS-2021-NR060112), Ministry of Science and ICT (RS-2026-25489499), and Ministry of SMEs and Startups (RS-2026-25529467) South Korea.

Poster Presentation

Potential of ATR-FTIR Spectroscopy and Molecular Parameters in Elucidating Immune Responses Associated with Burn Injury

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Burn injuries are the fourth leading cause of trauma worldwide with second-degree burns being highly prevalent. Early detection of immune response dynamics is crucial for effective burn management. This research aimed to develop a second-degree burn rat model and to investigate temporal immune response using ATR-FTIR spectroscopy in combination with molecular and biochemical techniques over 28 days. Thermal burns were induced (0.8 cm diameter) in SD rats (N = 35) using a heated stainless-steel rod. ATR-FTIR spectra were acquired from air-dried serum samples, and integrated AUC associated with cellular (TNF-α, IFN-γ, IL-1β/6/10) and humoral (IgG/M/A) immunity biomarkers were evaluated along with PCA analysis. WB analysis of cellular immunity biomarkers was also performed. Histology revealed early infiltration of inflammatory cells followed by progressive re-epithelialization on days 7 and 14. ATR-FTIR analysis showed significant enhancement of IgA and IgM areas on day 3, indicating early immune homeostasis, while IFN-γ and IL-10 were found enhanced on days 3 and 21, suggesting biphasic immune modulation. Comparative analysis indicated partial agreement between ATR-FTIR and WB findings; however, the trends were not directly superimposable. SDS-PAGE identified day 14 as a critical stage for collagen remodelling. Haematological parameters showed increased levels of leukocytes and platelet indices after day 14, while serum calcium levels were found to be elevated during the proliferatory phase. These findings demonstrate that our developed model illustrated a broader understanding of burn wound healing dynamics. We believe that ATR-FTIR spectroscopy could serve as a complementary technology for monitoring immune response dynamics.

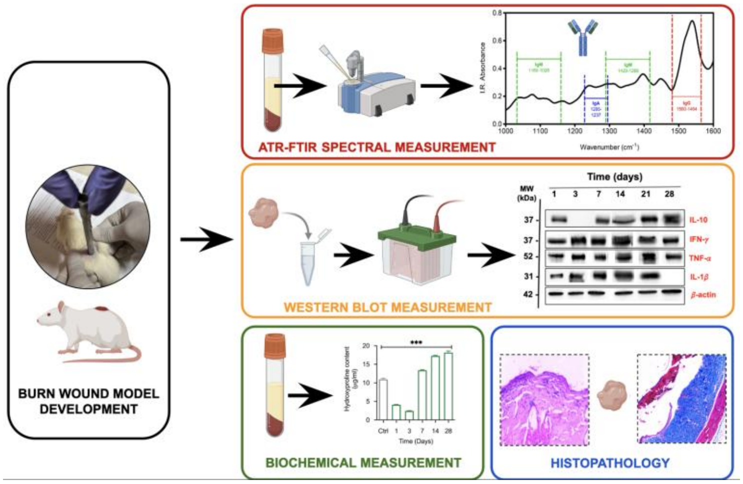

Fig. 1. Elucidation of immune responses using ATR-FTIR spectroscopy and molecular biology approach

Acknowledgement: The authors sincerely thank Dr. Sudhir Chandna, Director, INMAS, DRDO for their valuable support.

Poster Presentation

Improvement of bacterial enterobactin production by using atmospheric pressure non-thermal plasma

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Metal ions are essential for many biochemical reactions in bacteria, affecting their vitality and pathogenicity. Enterobactin is an iron-acquisition siderophore characterized by its exceptionally high affinity for ferric iron (Fe^{3+}), making it the most potent iron chelator known. It is typically synthesized by pathogenic bacteria such as *Escherichia coli* and other enteric species, and involved in the regulation of bacterial survival and pathogenicity by controlling the intracellular iron level [1]. In contrast to these pathogenic gut bacteria, *Rothia mucilaginosa*, a gram-positive coccus commonly found in the human oral cavity and respiratory tract, thrives as a facultative anaerobe. [2]. Non-thermal biocompatible plasma (NBP) has garnered considerable attention in the medical field owing to its promising capabilities [3].

This study investigates the impact of non-thermal plasma discharge on the growth and enterobactin synthesis of *R. mucilaginosa*. For non-thermal plasma treatment, the bacterial culture with an adjusted OD_{600} of 0.5 was prepared, and 20 µL of this culture was evenly distributed onto a sterile glass slide. After air-drying the glass slide for 30 minutes, plasma treatment was administered for durations ranging from 50 to 300 seconds [4]. The amount of enterobactin produced by *R. mucilaginosa*, as detected in the media, increased by up to 123.43% following treatment with the NBP soft jet. Plasma treatment significantly reduced the survival rate of *R. mucilaginosa* in a time-dependent manner.

The highest mortality rate was observed with a 150-second plasma treatment (92.89%), we selected colonies C (1-5) from the control group and E (1-15) from the 150-second plasma treatment group. The colonies were cultured individually, and enterobactin production was analyzed for each strain. Three strains with elevated enterobactin production were identified (E13, E14, and E15), with strain E14 exhibiting the highest enterobactin concentration in the medium, showing a 2.23-fold increase compared to the control. These findings suggest that NBP treatment may modulate secondary metabolite production in commensal bacteria, warranting further investigation into the mechanisms and potential applications of

NBP in controlled microbial metabolite production. This work was supported by the National Research Foundation of Korea (NRF) (RS-2021-NR060112, 2020R1F1A1070942).

References

[1] M. Amiri, M. Golchin, M. Jamshidian Mojaver, H. Farzin and A. Hajizade. Virulence, 16, 1, 2563018 (2025).

[2] C. C. Uranga, P. Arroyo, B. M. Duggan, W. H. Gerwick and A. Edlund mSystems. 5, 2, 10.11200161-20 (2020).

[3] Y. Li, J. H. Kim, E. H. Choi and I. Han. Sci. Rep. 9, 1, 3712 (2019).

[4] W. L. Wang Hong, Lyu Weifeng, Song Wenfeng, Hou Jingjie, Gou Min, Tang Yueqin J. Biol., 40, 6, 39 (2023).

Poster Presentation

Microscopic Plasma Discharges: A Potential application of Plasma Streamers in the Fabrication of Biomedical Plasma Apparatuses

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The discharge plasmas such as dielectric barrier or corona in the plasma processing of materials lead to the formation of sheath, presheath and bulk layers; and are often associated with the micro discharges comprising electron streams or simply streamers, cf. Fig. 1. [1]. The present work serves as a basic ingredient to calculate the source term in the Boltzmann kinetic equation which is just the function of the distribution function that changes with time in the presence of the electric field [2]. The streamers can be harnessed to generate plasma plume which has a potential application in the creation of biomedical plasma apparatuses. The low density of the electrons can be created by tuning the width of the sheath and presheath at the material surface enclosing discharge plasmas wherein electrons can diffuse away from the bulk plasmas. The separation of electrons and ions could be done through the utilization of positive and negative ion tilt trajectories associated with the sheath deformation technicalities to create an ion-plasma plumes in the domain of applications of plasmas in medicine. Furthermore, the quality of collimation and monochromatism can be controlled by the external electric field which is highly desirable in material processing .This scheme can effectively be employed to fabricate plasma devices in the domain of biomedical applications where positive ions or radicals play a crucial role in the stimulation of biophysical reactions [3].

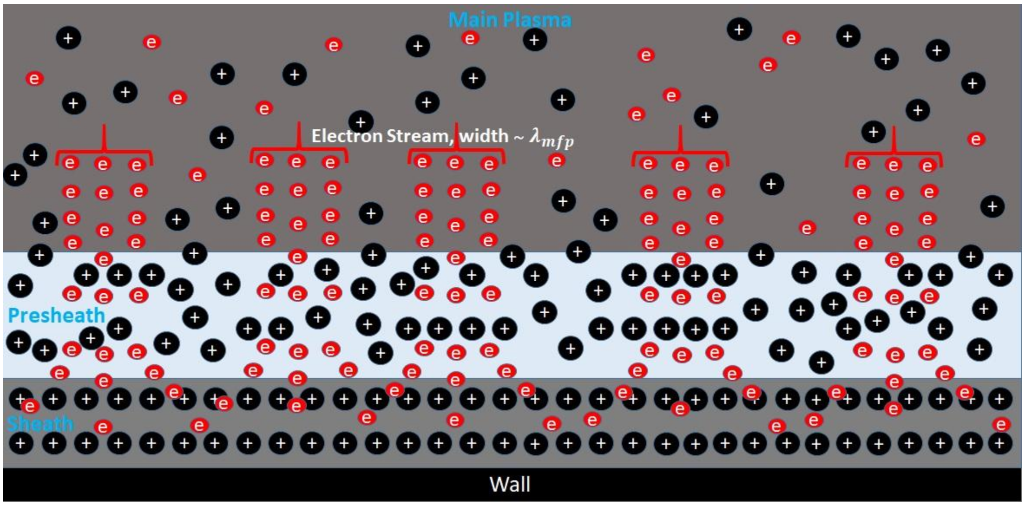

Fig. 1. Plasma Streamers of size of the order of mean free path () in the plasma regions

References

[1] P. K. Tiwari, R. Kumar, K. Halder and Y. S. Lee, *Journal of Russian Laser Research*, 44, 504 (2023).

[2] P. K. Tiwari, R. Kumar, and Y. S. Lee, Physica Scripta 100, 035613 (2025).

[3] Y. J. Kim, S. Jin, G. H. Han, G. C. Kwon, J. J. Choi, E.H. Choi, S. S. Uhm and G. S. Cho, IEEE Trans. Plasma Science 43, 944 (2015).

Poster Presentation

Optical Coherence Tomography: An Emerging Modality in Deep Tissue Imaging

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Optical Coherence Tomography (OCT) represents a transformative advancement in biomedical imaging, offering non-invasive, high-resolution (typically 5–10 µm axial resolution) cross-sectional visualization of biological tissues up to 2–3 mm depth. Operating on low-coherence interferometry principles akin to ultrasound but utilizing near-infrared light, OCT provides superior detail for microstructures, surpassing intravascular ultrasound (IVUS) in cardiology (10–20 µm vs. ~150 µm resolution) and enabling precise retinal layer segmentation in ophthalmology,. This paper comprehensively reviews OCT's evolution from time-domain to spectral-domain and swept-source variants, emphasizing extended depth-of-focus (E-DOF) probe designs incorporating step-index/graded-index fibers and Bessel-type lasers for enhanced deep-tissue penetration. Key applications span gynecology, ophthalmology, cardiology, and oncology. In a clinical case of a 28-year-old Asian male , OCT revealed right eye mean retinal thickness of 274.6 µm, confirming traumatic chemosis resolution without macular edema or detachment under normal ocular tensions .

This work was supported by Birla Institute of Technology,Mesra

References

[1] Aumann, S., Donner, S., Fischer, J., & Müller, B. Optical coherence tomography (OCT):Principle and technical realization. *Handbook of Clinical Neurology*, 160, 303–322(2019).

[2] Tiwari, P.K., Parmar, K.P., and Pandey, S., "Optical signal transmission through masked aperture to extend the depth of focus in optical coherence tomography," Majlesi J. Electr. Eng., Vol. 14, pp. 93–96, 2020.

[3] Bouma, B.E. and Tearney, G.J. (eds.), Handbook of Optical Coherence Tomography, Marcel Dekker, New York, 2002.

Poster Presentation

Synergistic Effects of Non-Thermal Plasma and Fungal Pretreatment on Sustainable Bioethanol and Nanocellulose Production using Used Coffee Ground

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Spent coffee grounds (SCG) represent a widely available agro-industrial byproduct with considerable potential for sustainable valorization into bio-based products(Karmee, 2018). This study proposes an integrated green biorefinery approach for converting SCG into bioethanol and nanocellulose through the synergistic application of filamentous fungus, *Neurospora crassa* and non-thermal plasma-activated pretreatment (NTP-AP). An ozone-producing non-thermal plasma system, combined with oxalic acid, was utilized to facilitate lignocellulosic biomass deconstruction, enhance cellulose accessibility, and promote the release of fermentable sugars under eco-friendly processing conditions. Key operational variables, including plasma treatment duration and pretreatment parameters, were optimized to maximize hydrolysis and fermentation performance(Lin et al., 2020).

Comprehensive physicochemical characterization was performed to assess structural changes in the biomass and evaluate the quality of the resulting products. The plasma-assisted oxalic acid pretreatment significantly improved biomass fractionation and fermentable sugar yield that might lead to enhanced bioethanol production. The findings demonstrate the effectiveness of integrating non-thermal plasma technology as a sustainable platform for biofuel generation and value-added biomaterial recovery from agro-industrial residues. Synergistic effects of fungal application on biomass destruction are under investigation. Furthermore, the residual biomass remaining after bioethanol production will be processed for nanocellulose extraction, reinforcing the principles of a circular and zero-waste biorefinery system.

This work was supported by the National Research Foundation of Korea (NRF) (RS-2021-NR060112, 2020R1F1A1070942) and Korea Agriculture Technology Promotion Agency (KOAT).

References

Karmee, S. K. (2018). A spent coffee grounds based biorefinery for the production of biofuels , biopolymers , antioxidants and biocomposites. *Waste Management*, *72*, 240–254. https://doi.org/10.1016/j.wasman.2017.10.042

Lin, S., Kuo, T., Wang, H., Ting, Y., & Hsieh, C. (2020). Bioresource Technology Enhanced bioethanol production using atmospheric cold plasma-assisted detoxification of sugarcane bagasse hydrolysate. *Bioresource Technology*, *313*(June), 123704. https://doi.org/10.1016/j.biortech.2020.123704

Poster Presentation

Engineering and Optimization of a Low Frequency Power Cold Atmospheric Pressure Plasma Jet for Biological Application

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Abstract

Cold Atmospheric Pressure Plasma (CAPP) jets have emerging filed and promising tools for material processing due to their ability to generate reactive oxygen and nitrogen species (RONS) at near-room temperature, enabling surface modification without thermal damage [1]. These reactive species play a vital role in various biomedical application or process while minimizing thermal damage to living tissue and cells, which make CAPP as a promising tool for healthcare and life science applications.

In this study, a Cold Atmospheric Pressure Plasma Jet (CAPP) was designed for cold plasma generation and successfully engineered and fabricated as primary need, along the plasma jet designed also focused on the appropriate power supply for plasma generation. For plasma generation on of the most important part is choose the power supply which cost effective and at the same it is also have more efficient. In our experiment we used a low frequency and high voltage power supply to generating cold atmospheric pressure plasma jet.

Successfully generating plasma jet further, we go for systematic characterization using Optical Emission Spectroscopy (OES) to identify the reactive species generated in the plasma [2]. The operating parameters of the jet were optimized by varying gas flow rate and discharge power using a 50 Hz AC power supply to achieve stable and reproducible plasma conditions.

The influence of these parameters on plasma characteristics and reactive species generation was carefully characterized and analyzed, as such optimization is crucial for effective plasma-assisted material processing and most importantly for biological application [3]. The optimized plasma jet is intended for future biological applications, including cell-based studies and plasma-mediated therapeutic investigations. This work provides a foundation for the development of cost-effective and efficient plasma systems for biomedical and healthcare applications.

References :

[1] J. Jaiswal et al., Appl. Surf. Sci. 703, 163347 (2025).

[2] R. Zaplotnik, G. Primc, and A. Vesel, Applied Sciences 11, 2275 (2021).

[3] J. LIU et al., Plasma Science and Technology 28, 035504 (2026)

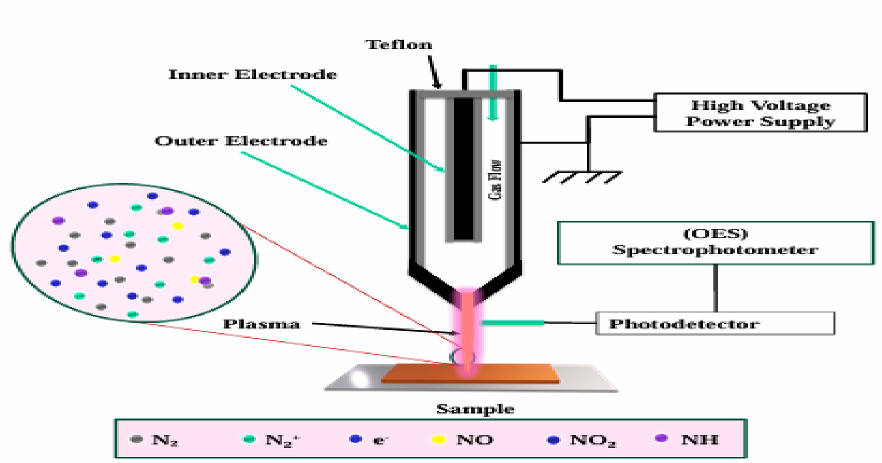

Fig. 1. Schematic Diagram of Low frequency Cold APPJ describing the plasma charactering using OES spectroscopy and plasma generating by a high voltage power supply (B) A nitrogen gas plasma jet is shown in the figure and its OES Spectra of Cold APPJ.

Poster Presentation

Ru-loaded on ZIF-67 for improving photocatalytic ammonia production

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Photocatalytic nitrogen reduction reaction (NRR) has emerged as a green and sustainable approach for ammonia production under ambient conditions. However, NRR is hindered by the high dissociation energy of the N≡N triple bond and the rapid spatial recombination, resulting in low ammonia production efficiency. To address these challenges, a metal organic framework (MOF), ZIF-67, was loaded different amounts of ruthenium (Ru) to enhance nitrogen adsorption and activation. The photocatalytic performances of ZIF-67, ZIF-Ru0.02, and ZIF-Ru0.05, ZIF-Ru0.1, ZIF-Ru0.25 and ZIF-Ru0.5 achieved ammonium (NH_4^+) production rates of 2,191 μmol g^{-1}, 1,438 μmol g^{-1}, 810 μmol g^{-1}, 8,376 μmol g^{-1}, 6,464 μmol g^{-1}, and 4,761 μmol g^{-1}, respectively, at 3 h of photocatalytic reaction in the presence of a sacrificial reagent. Among the synthesized photocatalysts, ZIF-Ru0.1 exhibited the photocatalytic NH_4^+ production performance approximately 3.8 times higher than pristine ZIF-67, demonstrating Ru loading strategy effectively enhances photocatalytic NH_4^+ production. Furthermore, UV–Vis diffuse reflectance spectroscopy (UV–Vis DRS) revealed a reduced bandgap after Ru incorporation, indicating improved visible-light absorption. FTIR analysis showed a shift in the N–H vibration of ZIF-67 after Ru loading, suggesting that Ru was successfully anchored to the organic linker sites. These findings provide the introduction of Ru-induced structural defects enhances the electronic structure and catalytic activity, thereby promoting efficient photocatalytic NH_4^+ production.

Fig. 1. Photocatalytic ammonium production performance using ZIF-67, ZIF-Ru0.02, and ZIF-Ru0.05, ZIF-Ru0.1, ZIF-Ru0.25 and ZIF-Ru0.5.

This work was supported by the National Research Foundation of South Korea (NRF) grant funded by the Korean government (Grant No. RS-2026-25472979 and 2021R1A6A1A03038785)

References

[1] X. Bai, L.-P. Liu, Y.-F. Xu, Y. Sun, W.-H. Sun, Z.-P. Deng, Y.-X. Sun, and L. Xu, Applied Surface Science, 722, 165545 (2026).

Poster Presentation

Experimental Characterization of a Dual Dielectric Barrier AC Plasma Jet for Biomedical Applications

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This study presents the development and experimental characterization of a dual dielectric barrier discharge (DBD)-based atmospheric pressure AC plasma jet designed to evaluate its suitability for biomedical applications.

Cold atmospheric pressure plasma (CAP) has attracted significant interest in plasma medicine owing to its ability to generate biologically active species under near-room temperature conditions. Unlike thermal plasmas, CAP can directly interact with living tissues without causing thermal damage [1].

A dual dielectric plasma source was constructed, with both the powered and grounded electrodes fully insulated to produce a stable AC plasma jet. Electrical characterization was performed using voltage-current (V-I) measurements, whereas optical emission spectroscopy (OES) was employed to calculate plasma parameters and optimize RONS generation. Gas temperature was measured using a K-type thermocouple, an infrared (IR) camera, and the rotational spectra of lines via LIFBASE software.

The present system ensured stable, spark-free plasma generation while maintaining a low gas temperature and efficient production of reactive oxygen and nitrogen species (RONS) [1]. The plasma jet was operated at varying voltages from 8kV to 12 kV, with a 35 kHz frequency and Ar gas flow rates of 3-6 lpm. From OES spectra, electron excitation temperature (T_{exc}) was found in the range from 0.5 to 0.7 eV, which was determined using the Boltzmann plot method, and an electron number density of 10^{12}-10^{14} cm^{-3} was estimated using the line intensity ratio method [2]. Gas temperature measurements using a K-type thermocouple, infrared (IR) camera and rotational spectra of OH lines analyzed with LIFBASE software showed gas temperatures between 28 and 40 ^{0}C, confirming the cold nature of the discharge.

The combination of stable discharge operation, efficient RONS generation, low electron excitation temperature, and ambient gas temperature, without any thermal effect, demonstrates that the developed dual dielectric AC plasma jet is a promising solution for biomedical applications [3].

References

[1] S. Das, S. Mohapatra, and S. Kar, *J. Appl. Microbiol.*, vol. 135, no. 9, p. lxae238, 2024, doi: 10.1093/jambio/lxae238.

[2] S. Rath and S. Kar, *Phys. Fluids*, vol. 37, no. 11, p. 117113, 2025, doi: 10.1063/5.0293788.

[3] S. Das, S. Mohapatra, and S. Kar, *Fundam. Plasma Phys.*, vol. 12, p. 100078, 2024, doi: https://doi.org/10.1016/j.fpp.2024.100078.

Poster Presentation

The Self-organizing Behavior in Ethylene Radio Frequency Plasma Discharge

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In this study, ethylene discharge was conducted in a capacitively coupled radio frequency plasma discharge system at 13.56 MHz. The self-organizing behavior in ethylene discharge was analyzed through the spatiotemporal evolution process of plasma glow and particle coagulation with the help of plasma spectral diagnosis, the Langmuir probe diagnosis, and discharge video and image diagnosis. The spatial distribution and the evolution of plasma glow, the coagulation process of micron-sized particles, the evolution of in situ scattered light intensity on the particles stimulate the related physical analysis, such as the influence of plasma parameters on particle coagulation process, particle polarization, dynamical evolution process of the self-organizing structures, phase separation of particles, etc. For example, the spatiotemporal evolution of the light scatter intensity on a vertical line shows that as the discharge time going on, the coagulated particles can form chain structures (Fig. 1) and the oscillation phenomenon of the particle chains was also observed. The corresponding models were constructed for further analysis on the spatiotemporal evolution of the discharge process and the dynamics of the self-organizing structures.

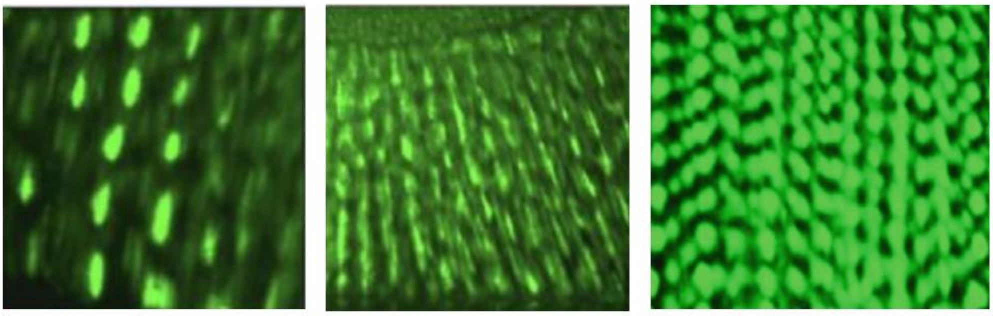

Fig. 1 Chain structures formed by the coagulated particles.

This work was supported by National Natural Science Foundation of China (Grant No. 12075315).

References

[1] Y. Liu, B. Li, et al., *Contrib. Plasma Phys.*, 64, e202300179 (2024).
[2] B. Li, W. Chen, et al. *Electronics,* 13, 983 (2024).
[3] B. Li, W. Chen, et al., *Rend. Fis. Acc. Lincei,* 35, 471 (2024).
[4] G. Shi, X. Tang, et al., *Plasma Physics Reports,* 49, 105 (2023)

Poster Presentation

Analytical Modelling for Predicting Methane Conversion and Hydrogen Yield in Non-Thermal Plasma-Assisted Methane Pyrolysis

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Hydrogen is often considered one of the most promising clean energy carrier because of its potential to deliver sustainable and low carbon energy. According to international energy agency (IEA), the global hydrogen demand reached about 100 million tonnes in 2024 and is expected to increase in the coming years . Consequently, non-thermal plasma has gained significant attention for hydrogen production through methane pyrolysis due to the its potential to generate CO_2 - free hydrogen under mild temperature . Although numerous studies have reported previously for the enhancement and optimization of methane conversion efficiency and hydrogen yield by varying the parameters for plasma reactors such as applied voltage, gas flow rate, discharge power, frequency, dilution of methene gas, residence time, etc . However, a generalized analytical framework relating these parameters to reactor performance is still lacking. In the present work, an analytical model is proposed to describe the methane conversion as a function of methane gas flow rate and applied voltage. The model is formulated using the concept of total differential by incorporating experimentally observed trends reported in the literature. Validation of the proposed model using reported data of different plasma reactor system from literature will be presented in the conference. The proposed analytical framework provides interpretation of reported experimental trends and offers a foundation for reactor optimization, parameter analysis, and future validation across different non-thermal plasma reactor configurations.

References

[1] Z. M. Sarkinbaka and M. K. Marvin, “Towards plasma-assisted methane pyrolysis for hydrogen production: A review,” *Next Energy*, vol. 12, p. 100700, Jul. 2026, doi: 10.1016/j.nxener.2026.100700.

[2] P. Chawdhury, S. Bhanudas Rawool, M. Umamaheswara Rao, and Ch. Subrahmanyam, “Methane decomposition by plasma-packed bed non-thermal plasma reactor,” *Chem. Eng. Sci.*, vol. 258, p. 117779, Aug. 2022, doi: 10.1016/j.ces.2022.117779.

[3] M. M. Moshrefi and F. Rashidi, “Hydrogen Production from Methane Decomposition in Cold Plasma Reactor with Rotating Electrodes,” *Plasma Chemistry and Plasma Processing*, vol. 38, no. 3, pp. 503–515, May 2018, doi: 10.1007/s11090-018-9875-5.

[4] M. Cao, S. Li, S. Wang, X. Zhou, G. Ma, and Y. Chen, “Enhanced Hydrogen Production via Methane Cracking in a Dielectric Barrier Discharge Plasma Reactor: Structural and Operational Parameter Optimization,” *Ind. Eng. Chem. Res.*, vol. 65, no. 16, pp. 8233–8243, Apr. 2026, doi: 10.1021/acs.iecr.5c05406

Poster Presentation

Plasma process for controlled magnetron sputtered tricalcium phosphate films for antimicrobial efficacy for orthopedic implants

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Tricalcium phosphate (TCP) and Ag-doped tricalcium phosphate (Ag-TCP) thin films have attracted significant interest as multifunctional biomaterials owing to their ability to simultaneously promote osseointegration and inhibit bacterial colonization, making them attractive candidates for next-generation orthopedic and dental implants. Achieving these functionalities requires precise control of plasma-assisted film growth, where the energy and flux of plasma species govern the evolving microstructure, composition, and biological response of the coatings. In this work, TCP and Ag-TCP thin films were synthesized by unbalanced RF magnetron sputtering, and the plasma–surface interactions governing film formation were systematically investigated using an integrated diagnostic approach combining Langmuir probe measurements, optical emission spectroscopy (OES), and energy flux diagnostics. The plasma diagnostics provided quantitative insight into electron density, electron temperature, plasma chemistry, and the energy delivered to the growing films, establishing direct correlations between discharge characteristics and coating evolution. Tailoring the plasma environment enabled controlled Ag incorporation, preservation of Ca/P stoichiometry, enhanced crystallinity, dense nanostructured morphology, and optimized surface characteristics. These plasma-engineered coatings exhibited improved antibacterial activity against *Staphylococcus aureus* while maintaining the intrinsic bioactivity of TCP, demonstrating an effective balance between antimicrobial functionality and biocompatibility. The study highlights the critical role of advanced plasma diagnostics in understanding plasma-assisted materials processing and provides a robust strategy for designing multifunctional bioactive coatings with controlled ion release, superior structural integrity, and enhanced biological performance for industrial and biomedical applications.

Acknowledgement: The authors gratefully acknowledge IIT Delhi for extending the CRF facility for different sample analyses. This work was sponsored by the ICMR funded project with file number EMDR/SG/10/2024-04802.

References

[1] X. Ni, J. Feng, M. Liang, F. Zhou, Y. Xia, Z. Dong, Q. Xue, Z. Li, F. Pu, and P. Xia, Orthop Res Rev., 17, 313–340 (2025).

[2] A. Topsakal, N. Ekren, O. Kilic, F.N. Oktar, M.M.O. Ozkan, H.T. Sasmazel, M. Turk, I.M. Bogdan, G.E. Stan, and O. Gunduz, J. Mater. Sci. Mater. Med., 31, 16 (2020).

Poster Presentation

Cold Atmospheric Plasma Technology Enabling Fabrication of Peptide-Based Supramolecular Gels for Potential Electrochemical Applications

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Self-assembly is the spontaneous, free-energy-driven association of building blocks into organized and functional architectures. It is a ubiquitous process in nature and is paramount for sustaining life [1]. Subsequently, the self-assembly of proteins/peptides has been studied extensively due to its ability to form bio-inspired functional materials with excellent bio-compatibility and additional utility in regenerative medicine and bioengineering [1,2]. Inspired by the remarkable properties of self-assembling peptides, our work aims to explore Cold Atmospheric Plasma (CAP) technology for modulating the bio-molecular self-assembly of selected peptides.

CAP has garnered significant attention into multiple disciplines recently, owing to the diverse reactive species it generates [3]. It can interact with biological molecules, modulating their self-assembly, modify amino acid side chains, induce redox reactions, and alter solvent properties by varying weak or non-covalent interactions. In this work, the tri- and tetra-peptides were irradiated using an in-built CAP setup, resulting in the formation of soft, fibrillar hydrogels having network-like assemblies. We have employed multiple biophysical techniques, including fluorescence and electron microscopy, to investigate the morphology of these fibrous assemblies, and several spectroscopic analyses to elucidate the mechanism of Cold Atmospheric Plasma-assisted gelation. The in-fluence of distinct aromatic moieties, in combi-nation with charged amino acid residues within the peptide sequence, and their competing in-termolecular interactions was systematically investigated, revealing their role in governing the resulting morphological diversity. Additionally, electrochemical impedance spectroscopy (EIS) of the resulting soft gels revealed enhanced electrical conductivity in the CAP-treated peptide assemblies. We have further optimized the plasma parameters, achieving a significantly low Critical Gelation Concentration (CGC) of the peptides. This study demonstrates that CAP provides a novel approach for rapid, tunable gelation of peptide hydrogels without chemical additives, offering

significant potential for the development of functional biomaterials for biomedical applications.

This work was supported by ICMR Project grant and IASST, Guwahati, in-house project grant.

References

[1] Frederix, P., Scott, G., et al., Exploring the sequence space for (tri-)peptide self-assembly to design and discover new hy-drogels, Nature Chem 7, 30–37

[2] Wang, T.; Ménard-Moyon, C.; Bianco, A. (2024). Structural Transformation of Co-assembled Fmoc Protected Aromatic Amino Acids to Nanoparticles, ACS Appl Mater Interfaces, 16 (8), 10532–10544

[3] Bhatt P., Das P., and Sankaranarayanan K., (2025), Stimuli-responsive gelation of Fmoc-l-tyrosine derivatives to form supra-molecular architectures via cold atmospheric plasma treatment, Phys. Chem. Chem. Phys.,27, 24969-24985

Poster Presentation

Atmospheric Pressure Dielectric Barrier Discharge Plasma for Pesticide Remediation in Model Soil: GC-MS Analysis, Degradation Mechanisms, and Toxicity Evaluation

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The widespread use of pesticides has led to significant environmental contamination, necessitating the development of efficient and sustainable remediation technologies. Atmospheric Pressure Cold Plasma (ACP) produced by dielectric barrier discharge (DBD) offers an eco-friendly and innovative method for remediating pesticide-contaminated soil, addressing serious environmental and health concerns (Jangra et al., 2026; Sarangapani et al., 2016). However, the application of emerging non-thermal plasma technology, such as ACP-DBD, holds great promise in mitigating this issue effectively and sustainably. The ACP-DBD produced filamentary discharges generating reactive species such as reactive oxygen and nitrogen species (RONS), hydroxyl radicals (•OH), ozone (O3), and nitrogen oxides (NOx) (Czapka et al., 2018). This study investigates the use of a high-voltage Dielectric Barrier Discharge (DBD) plasma reactor for the degradation of deltamethrin (DELTA). Cocopeat was used as a model soil to simulate field conditions. The degradation efficiency of DELTA was significantly influenced under optimized conditions, and the degradation efficiency significantly improved, reaching 84.5 % after 15 minutes of plasma treatment. The GC-MS analysis was conducted to derive the intermediate compounds, and a possible degradation mechanism has been proposed. The toxicity tests have been conducted to check the toxicity of the intermediate compounds using the Toxicity Estimation Software Tool. The results of these efforts will be presented.

References

[1] Czapka, T., Maliszewska, I., & Olesiak-Bańska, J. (2018). Influence of Atmospheric Pressure Non-thermal Plasma on Inactivation of Biofilm Cells. Plasma Chemistry and Plasma Processing, 38(6), 1181–1197. https://doi.org/10.1007/s11090-018-9925-z

[2] Jangra, S., Mishra, A., Mishra, R., Pandey, S., & Prakash, R. (2026). Effective degradation of DELTA pesticide in soil by an atmospheric-pressure cold plasma-DBD system. RSC Advances, 16(3), 2585–2596. https://doi.org/10.1039/D5RA08882H

[3] Sarangapani, C., Misra, N. N., Milosavljevic, V., Bourke, P., O'Regan, F., & Cullen, P. J. (2016). Pesticide degradation in water using atmospheric air cold plasma. Journal of Water Process Engineering, 9, 225–232. https://doi.org/10.1016/j.jwpe.2016.01.003

Poster Presentation

Plasma-Mediated AI Enabled Breath Biosensor for Respiratory Disease Diagnostics and Therapeutics

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Abstract- Recent advancements in plasma chemistry, plasma medicine, biomedical sensing, and computational healthcare have aided the development of intelligent non-invasive systems for respiratory disease diagnostics and therapeutics. Conventional spirometry-based methods often fail to capture molecular and biochemical alterations associated with pulmonary disorders, while existing breath-analysis systems suffer from limited sensitivity and inadequate integration with respiratory physiology. This work proposes an AI-guided plasma-enabled multimodal respiratory platform integrating plasma-assisted biosensing, spirometry-based pulmonary monitoring, and cold atmospheric plasma (CAP) therapeutics within a unified computational framework. Plasma-engineered nanostructured sensing interfaces based on zinc oxide, graphene derivatives, ferrites, and carbon nanotubes are employed to enhance gas adsorption sensitivity and signal transduction. The system targets clinically relevant biomarkers including nitric oxide, acetone, methane, ammonia, and volatile organic compounds associated with asthma, COPD, pulmonary infections, and inflammatory airway diseases. Explainable AI models integrate sensor outputs with spirometry parameters for disease prediction and characterization such as normal, restrictive, obstructive and mixed lung diseases toward next-generation intelligent respiratory healthcare systems.

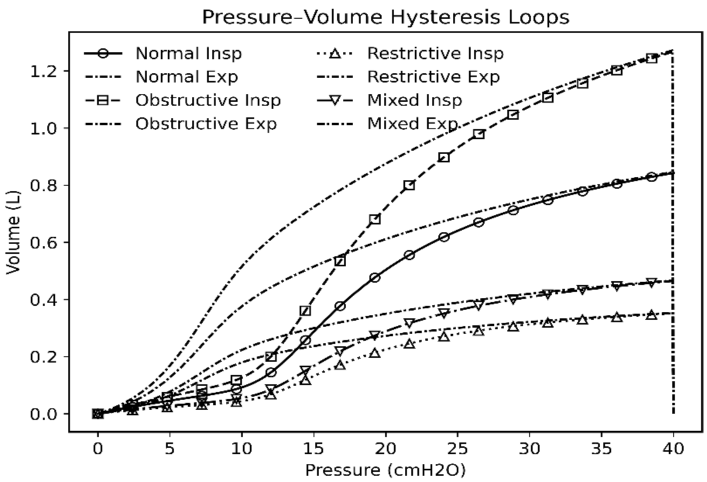

Fig.1 AI-guided mini cold atmospheric plasma nebulization system for plasma-assisted respiratory diagnostics, airway therapeutics, and intelligent pulmonary healthcare.

Acknowledgments – The authors acknowledge SAIL Hospital, Chasnalla, for their support, guidance, and assistance in spirometry data collection and clinical analysis.

References

[1] S. R. K. Murthy, T. Zhuang, J. Canady, *Scientific Reports*, 16, 47349 (2026).

[2] P. K. Tiwari, R. Kumar, and Y. S. Lee, *Physica Scripta*, 100, 035613 (2025).

[3] M. G. Levitzky, *Pulmonary Physiology*, 7th ed., McGraw-Hill Education, New York (2003).

Poster Presentation

Integrated Multi-Layered Security Technologies for Critical Infrastructure Protection: UAV Platforms, AI Surveillance, Counter-UAS and Industrial Cyber Security

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This presentation outlines the 2026 technology portfolio of Innovative Technologies; an integrated suite of security solutions built on Israeli defence-industry expertise and directed at the multi-layered protection of critical infrastructure and private-sector assets. The portfolio spans four connected domains. Aerial platforms include a fully autonomous fixed-wing eVTOL drone for ISR, border protection and infrastructure missions, the Sentinel quadcopter family in heavy-payload, high-endurance and compact configurations, and the SAMS autonomous perimeter-monitoring system with a tethered variant for persistent surveillance. Intelligence and AI sensing capabilities comprise EO/IR imaging payloads, embedded AI computing for image enhancement and target tracking, and the EyeFox automated threat-detection solution. Counter-UAS capability is provided through a multi-layer anti-drone architecture for detection and neutralisation, configured for maritime, portable, vehicle-mounted, VIP-transport and fixed-installation deployment. Supporting infrastructure and cyber services complete the ecosystem, including an automated drone hub with battery swapping, ground control systems, and security architecture and design services for industrial control systems. Taken together, these solutions emphasise autonomous operation, reduced operator cognitive load, and rapid response across civilian, industrial and high-threat environments.

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