



प्लाज़्मा अनुसंधान संस्थान
Institute for Plasma Research

Facilitation Centre for Industrial Plasma Technologies
Institute for Plasma Research

Plasma Processing Update

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FCIPT Main Office Building



FCIPT Research and Development Building



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Important Highlights

- Alternative to pesticides
- Can kill bacteria, fungi, microorganism
- Oral hygiene and teeth whitening
- Food preservation
- Enhanced seed germination

Microbial Inactivation using Plasma Activated Water

Plasma-activated water (PAW) refers to water exposed to non thermal or thermal plasma where chemical species formed interact with water during or after the plasma discharge is switched off. This is an emerging field and has many applications in killing harmful micro-organisms to cure various skin diseases and has the potential to eliminate the use of pesticides in agriculture. Studies suggest that plasma activated water contains reactive nitrogen species (RON) including nitrous (NO_2^-) and nitric (NO_3^-) oxides and reactive oxygen species (ROS) such as peroxy radicals (OOH) and hydrogen peroxide dissolved in it. Electrons get attached with the oxygen species and assist in scavenging the oxidation reactions. Recent research has shown that microbial cells can be killed when they are exposed to plasma activated water.

FCIPT, Institute for Plasma Research has developed a novel apparatus and process to produce activated water using non-thermal plasma. The initial chemical and microbial analysis has been carried out with the help of Gujarat Environment Management Institute, Gandhinagar. The chemical analysis results of plasma activated water are mentioned in Table 1.

Sr. No.	Parameters	Value
1.	pH	2.5 – 8.5
2.	NO_2^-	21.6 mg/L
3.	NO_3^-	181.8 mg/L
4.	H_2O_2	++ (present)
5.	Oxidation Reduction Potential	+450 to + 650 mV

Table1: Results of chemical analysis of plasma activated water

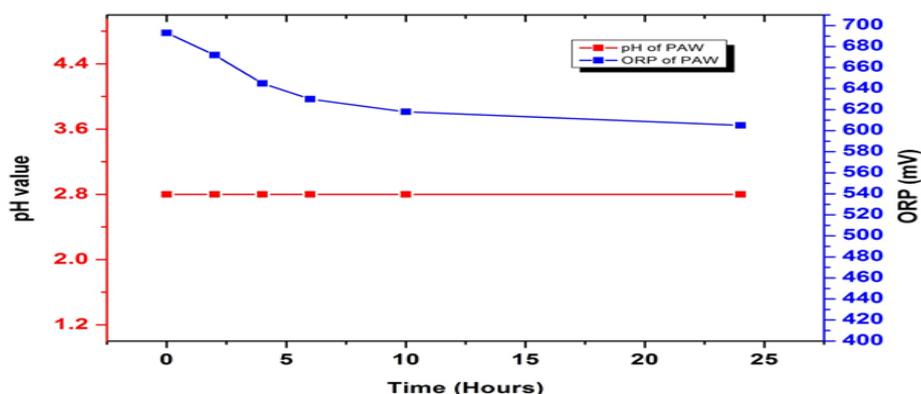


Figure 1: Change in pH & ORP of Plasma activated water with time (pH of untreated water is 6.8 and ORP value is +200mV)

Figure 1 clearly indicates that pH of plasma activated water does not change with time. However, the oxidation-reduction potential (ORP) reduces initially and gets stabilized after 24 hours. The initial reduction in ORP value may be due to degasification of dissolved ozone. Detailed studies will involve understanding the properties and antimicrobial efficacy (selected spores and bacteria) of plasma activated water (PAW). The composition and antimicrobial property of PAW will be monitored over a time period. The study will also include the use of PAW in agriculture to eliminate harmful pesticides. FCIPT, IPR has signed an MoU with Anand Agriculture University and with their help a systematic study to determine the effect of PAW on killing of harmful micro-organism and its effect on photo-synthesis (growth of plant) is planned.



Figure 2: Image of tomatoes washed by plasma activated water and normal water (image taken on 40th day of washing)

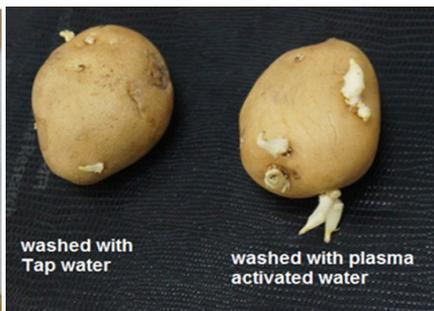


Figure 3: Image of Potatoes washed with tap water and plasma activated water shows higher germination in PAW treated potatoes



Figure 4: PAW System Developed by FCIPT

Growth study of E.Coli bacteria exposed to PAW

- This study was done by GEMI (Gujarat Environment Management Institute) using PAW supplied by FCIPT, IPR
- For this study, 99ml of PAW was mixed with 1 ml of E.Coli bacteria solution.
- The mixture was then taken out at various intervals and incubated using Agar solution and incubator for approximately 24 hours.
- It was found that in 30 minutes E-Coli microorganisms were completely killed. The test was continued for longer duration and no growth was observed.

Time (min)	PAW Water (99 ml) + E-Coli Solution (1 ml)	Controlled Sample Test : DM water (99 ml + E-coli solution (1 ml)
0		
15		
30		
45		
60		

Figure 5: Growth study of E.Coli. Bacteria exposed to PAW water vs. DM Water



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Important Highlights

- Enhanced food preservation
- Boosts seed germination and quality of agro-products
- Deactivates bacterial spores and fungi
- Stable and user friendly system

Atmospheric plasma system for food processing

Atmospheric pressure plasma technology (APP) involving the use of non-thermal plasmas is an emerging technique for the improvement of food preservation and food safety. Atmospheric pressure plasma discharge causes changes in the reactive oxygen species (ROS), reactive nitrogen species (RNS), pH, oxidation reduction potential and electrical conductivity. These changes in turn affect the seed germination, plant growth and quality of the agricultural product. Plasma treatment can also modify the surface of seeds to increase seed soaking.

Atmospheric pressure plasma technology also offers great promise as a technique for food safety. It can lead to inactivation of bacteria, bacterial spores, and fungi on the surface of fresh and processed food. In some preliminary studies conducted in collaboration with Anand Agricultural University, very promising results were found on removal of the pesticides from the surface of cabbage and chili samples.

FCIPT, IPR has developed an atmospheric pressure plasma system for food processing with continuous feeding of the food processing material. The material continuously passes through the plasma zone for exposure times ranging from few seconds to minutes. After processing the food properties are analyzed and if required plasma exposure times are varied. A unique design of the plasma electrodes and electronics makes the system very stable and user friendly.



Figure 1: Atmospheric Plasma System developed by FCIPT, IPR



Figure 2: Plasma zone between the electrodes

Past Events

ADMAT Conference

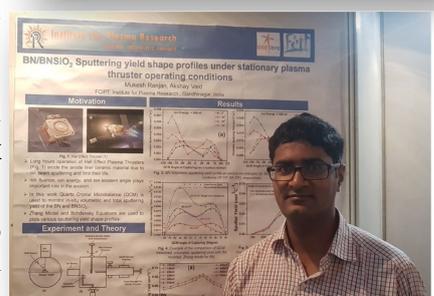
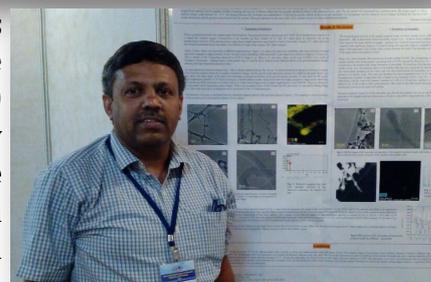
IPR participated in the International Conference on Advanced Materials & Processes (ADMAT 2017) organized by VSSC-ISRO, SAME, ASM, IIM, MRSI, NIAS and INAE from 14-16 Dec, 2017 at Kovalam, Trivandrum, Kerala, India. The focus of the conference was “Make in India, Fly in Space: Enabling Materials and Processes”.

IPR exhibited a stall at the ADMAT 2017 exhibition showcasing various areas of competence of IPR. Capabilities & competence of IPR scientists relating to mathematical modelling of thrusters, thruster material characterization, coatings and surface modification technologies related to space, cryo pump technology etc.

were showcased. Specifically, the contributions of projects executed by FCIPT for space applications were emphasized. The FCIPT division of IPR has been closely associated with various ISRO units and has developed facilities in the past which are routinely used for large area physical vapour deposition coatings, surface modification, plasma nitriding for surface hardening, plasma interaction with satellite components and sputtering yield measurements of space components. The participation of IPR in this conference also resulted in new collaboration possibilities between various units of ISRO and IPR

Besides the stall, IPR scientists also gave talks and presented posters at the conference. Dr. Nirav Jamnapara gave an invited talk on “Plasma based surface modification technologies for high temperature applications in space and aerospace sectors”. The talk, while focusing on results related to high temperature coatings and processes using plasma technology, also emphasized on various other plasma based materials processing applications undertaken by FCIPT in the past for different ISRO centres. Dr. Mukesh Ranjan presented a poster on his work on “BN/BNSiO₂ sputtering yield shape profiles under stationary plasma thruster operating conditions”.

In this work a QCM sensor is used to capture the eroded mass in vacuum and sputtering yield of material is estimated under various operating conditions relevant to actual plasma thruster conditions. Dr. Balasubramanian (co-authored by Jigar Patel, A. Satyaprasad and C. Sasmal) presented a poster on the “Growth of silicon carbide nanowires and nanotubes by thermal arc plasma process”, which was well received by the participants



Dr. Balasubramanian (Top)
and Dr. Mukesh Ranjan
(Bottom) with Poster

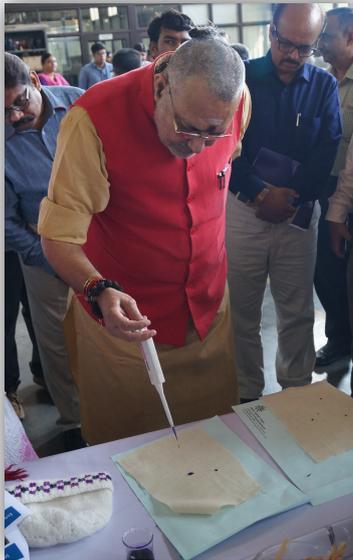
Past Events

Visit by Shri. Giriraj Singh to FCIPT

Shri Giriraj Singh, Minister of State for MSME, Govt. of India, visited FCIPT on 10th Oct 2017. He was accompanied by Shri Sanjay Hedao, Director - KVIC; Shri B. N. Sudhakara, Director – MSME Development Institute, Shri Jaikrishna, PS to MoS and other members of KVIC.

The Minister had visited the IPR stall at the Parliament House Annexe, New Delhi during 28th July to 11th August 2017 and had shown keen interest in using plasma technologies in areas of interest to MSME such as plasma nitriding for tool rooms etc.

The visitors were initially given a brief presentation about the technologies being developed by FCIPT. They were then shown several of the technologies developed in-house.



Plasma Textile Technology Lab



Nitriding Facility



Nano Technology Lab



Plasma Jet Facility



The Minister mentioned that his ministry was in the process of promoting khadi prepared with natural dyes and expressed that scientific R&D inputs from FCIPT to determine the role of plasma technology in improving dye uptake or colour fastness would be appreciated. The MoS also appreciated the work being carried out on societal applications of plasma and suggested many areas where plasma technology could possibly help.

Past Events

PTBT-2017

A two day symposium on “DAE-BRNS Symposium on Plasma and Allied Technologies for a Better Tomorrow” was organized at Institute for Plasma Research on 7-8th December 2017 to showcase plasma based technologies aiming to enhance the quality of life. The presentations during the symposium covered various topics on societal and industrial applications of plasmas viz. health care, agriculture, food, water and waste management. This event was also held to commemorate 20 years of Facilitation Centre for Industrial Plasma Technologies (FCIPT).





DAE-BRNS Symposium
ON
PLASMA AND ALLIED TECHNOLOGIES FOR BETTER TOMORROW
PTBT-2017

Sponsored By - Board of Research in Nuclear Sciences
7th -8th December 2017
Institute for Plasma Research (IPR)
Gandhinagar




Prof. P.I. John, Padma Shri awardee and founder of FCIPT, Prof. Abhijit Sen and Prof. Y. C. Saxena, members of FCIPT council, Prof. K.S. Ganesh Prasad and Prof. S. Mukherjee former division heads of FCIPT were the dignitaries invited. The chief guest for this event was Dr. Jayanti Ravi, Health commissioner of Gujarat Government. More than 65 participants from industries and academia attended the symposium. The program started with a welcome address by the convener followed by welcoming the distinguished guests with a bouquet of flowers. The event started with lighting of the ceremonial lamp by the distinguished guests. This was followed by the felicitation ceremony by IPR Director Prof. Shashank Chaturvedi where he felicitated our distinguished guests with shawls and mementos. Our guests then spoke about the happenings at FCIPT and wished FCIPT success for the coming years.

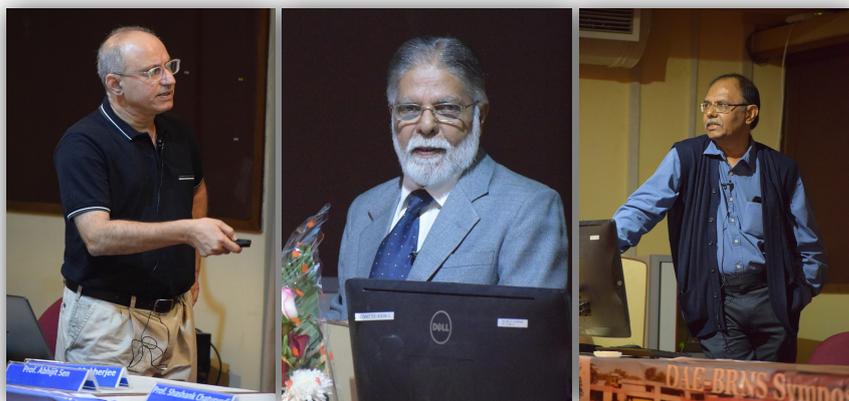


Padma Shri Prof. P.I. John, founder of FCIPT, lightning up the ceremonial lamp during inauguration

Prof. Shashank Chaturvedi, director, IPR gave a talk on “Overview of IPR Technologies for Societal Benefit”. There were two plenary lectures during this event :

1 A Vision for FCIPT: Emerging Opportunities in Plasma Processing by Prof. P.I. John

2. Emerging Trends in Water Purification by Dr. P.K. Tiwari, Raja Ramana Fellow, BARC



Prof. Shashank Chaturvedi

Prof. P.I. John

Dr. P.K. Tiwari

The two day symposium had 6 sessions and the talks under these sessions were as follows:

a. Plasma Medicine Applications

- Raman Spectroscopy: A potential tool in cancer management
- Nano patterning by plasma to detect early formation of abnormalities
- Cold Plasma Application of Skin Disease Treatment
- Potential uses of non-thermal plasma - an ophthalmologist's perspective

b. Plasma for Textile Application

- Plasma Industrial Applications in Jeans Fading and Woolens Shrink Proofing for Greener Tomorrow
- Atmospheric Plasma Treatment for Textile and Plastics
- Applications of DLC coating for Automobile Industries

c. Thermal Plasma Application

- Air plasma gasifier technology: A road map from dirty waste to clean environment and useful energy
- Plasma Pyrolysis, an eco-friendly method to dispose waste
- Present and Future of Waste Remedial Technologies in India
- Growing Industrial Applications of Metallic and Metal Oxide NanoPowders

d. Plasma Based Coatings

- Plasma based diffusion coatings
- Evaporation and Condensation over permeable surface for water harvesting
- Importance of Plasma Processing in Development of Novel Biomaterials
- Plasma Application in Agriculture

e. Applications of Non-Thermal Plasma

- Importance of Surface Engineering Through Atmospheric Pressure Plasma Various Strategic Applications
- Plasma Based Sterilization

f. Technology Commercialization

- Collaboration and Technology Commercialization
- Funding Possibilities in BRNS for Plasma Based Technologies

On day one of the seminar there was a visit to the labs at FCIPT where the participants were able to see a demonstration of the plasma nitriding of actual components, physical vapour deposition set up, solar cell set up, Angora processing system, nano-synthesis production system, Plasma pyrolysis and thermal plasma laboratory.



Solar Lab



Nitriding Facility



Plasma Torch Lab



Textile Applications Lab



Nano Lab



Pyrolysis Model



Dr. S.K. Nema, Prof Shashank Chaturvedi, Dr. Jayanti Ravi and Prof. P.I. John during panel discussion

During the session on Thermal Plasma Application, there was a panel discussion presided over by our chief guest Dr. Jayanti Ravi, Prof. Shashank Chaturvedi, Prof. P.I. John and Dr. S.K. Nema. Various issues on the persisting problems of waste destruction were discussed openly. Many participants expressed their concerns on the growing pollution of air and water and suggested that IPR along with other government agencies should work together for an alternative solution using plasma to curb air and water pollution. All the talks were well attended by the participants and all the sessions were quite interactive.

In the end of the session Dr. S. K. Nema gave the vote of thanks. A visit to Aditya and SST1 Tokamaks at IPR was organized for the participants.



PTBT-2017 Group Photo

PTBT - 2017 Organising Team: Dr. Alphonsa Joseph, Dr. Nirav Jamnapara, Dr. Mukesh Ranjan, Mr. P.V. Murugan, Mr. Satyaprasad, Mr. Anand Visani, Mrs. Nisha Chandwani and Mr. Kushagra Nigam

We thank IPR and FCIPT for making PTBT-2017 a great success!!!

“Plasma for a Sustainable Tomorrow”

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