

CONTENT

1. CAIPIRINH₃A CONCEPT
2. INTERVIEW WITH THE COORDINATOR
3. CAIPIRINH₃A CONSORTIUM
4. ACTIONS - 1st YEAR OF PROJECT
5. KNOWLEDGE REPOSITORY
6. UPCOMING EVENTS - NEXT STEPS
7. MATERIALS - DISSEMINATION CORNER

NEWS LETTER

#1



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VISION

CAIPIRINH₃A CONCEPT

CAIPIRINH₃A is an EU funded project under the umbrella of Horizon 2.5 Climate, Energy and Mobility Programme. CAIPIRINH₃A's vision is to set the foundation for the next-generation combustion technology leveraging the power of liquid-ammonia.

There is a growing demand for scalable, clean, and secure alternative fuels capable of powering various sectors, including maritime, aviation and heavy transport and energy production, without contributing to greenhouse gas emissions.



Although ammonia (NH₃) checks all the boxes as a zero-carbon fuel with its renewable production pathways, existing infrastructure, and reasonable energy density, the major challenge lies in developing a tailored combustion system that can overcome its low ignition reactivity, avoid harmful nitrogen oxides (NO_x) or nitrous oxide (N₂O) formation, and prevent unburned ammonia slip.

At the core of the CAIPIRINH₃A project is the design and fabrication of the next-generation ammonia combustor, the Plasma Mist Ammonia Burner (PlasMi-NH₃), which will be the culmination of CAIPIRINH₃A research and technologies into one prototype.

This approach aims to create a robust and optimised combustion environment potentially representing a significant step towards a climate-neutral, resilient energy system in Europe directly contributing to EU energy and climate goals.

TARGET

CAIPIRINH₃A CONCEPT

CAIPIRINH₃A targets several ambitious performance indicators:

- Thermal efficiency on par with conventional diesel engines (~40%)
- NO_x emissions compliant with Tier 4 standards (≤7.5 g/kWh)
- Reduction in ignition delay by over 50%
- Extension of the flammability limits by more than 20%
- Near-zero ammonia slip in the exhaust (<10 ppm)
- No reliance on auxiliary ignition or post-combustion cleanup system

The development and validation of the PlasMi-NH₃ burner will progress towards Technology Readiness Level 4 (TRL 4), with lab-scale hardware and testing campaigns designed to generate real combustion data under controlled conditions.



RECIPE

CAIPIRINH₃A CONCEPT

The PlasMi-NH₃ concept builds on advanced NH₃-plasma kinetics to leverage plasma synergy for optimised combustion performance. This approach enables the design of tailored injection and plasma systems that enhance ignition and open reaction pathways not accessible under conventional thermal conditions.

It will be integrated with a smart, machine-learning-enabled control system that continuously adjusts combustion parameters in real time to minimise emissions and ensure efficient ammonia burning. All CAIPIRINH₃A modules will be integrated into the PlasMi-NH₃ burner, complemented by holistic assessments addressing its societal, sustainability, and economic feasibility.



INTERVIEW

WITH THE COORDINATOR

To introduce the project, there is no better starting point than the insights of Dr. Kourtzanidis, whose expertise and leadership are central to its vision and served as the igniting force that forged this unique consortium.



DR. KOURTZANIDIS KONSTANTINOS
SENIOR RESEARCHER

CERTH - Centre for Research & Technology Hellas
CAIPIRINH₃A COORDINATOR

Dr. Konstantinos Kourtzanidis received his MSc in aerospace engineering and his PhD in fluid dynamics and plasma engineering from ISAE-SUPAERO (Toulouse, France). He holds a bachelor and MEng degree from the mechanical engineering department of Aristotle University of Thessaloniki (Greece). He spent several years in researcher positions at the University of Texas at Austin (USA) as well as at ONERA – the French aerospace lab (France). Since 2020, he is a Researcher at CERTH the Centre for Research and Technology Hellas (Thessaloniki, Greece), focusing on low temperature plasma theory and multiphysics simulations in the energy, aerospace and environment sectors. He co-leads the Plasma Science and Innovations (PlaSci) research team in the ARTEMIS laboratory of the CERTH's Chemical Process and Energy Resources Institute (CPERI).

What inspired the concept behind CAIPIRINH₃A, and what is the story behind its name?

The project is a direct response to the global and urgent need for alternative, clean and carbon free fuels to mitigate climate change and secure Europe's

independence in critical sectors: from transportation to power generation, our communities need to be «fueled» in a sustainable and environmentally friendly way. The CAIPIRINH₃A technological paradigm aims to put ammonia in the forefront of net-zero strategies for energy conversion.

Inspired by the homonymous world-famous cocktail caipirinha, our project aims to generate a truly vibrant and multiphase cocktail of chemical species which will activate multiple synergetic effects for enhanced combustion of liquid ammonia. This plasma-induced cocktail is the core scientific breakthrough that will enable clean and efficient ammonia combustion.

Why did you choose to focus on ammonia as a fuel over hydrogen? What do you think people should understand about ammonia as a fuel compared to hydrogen?

Similar to hydrogen (H₂), ammonia (NH₃) is another carbon and sulphur free, combustible molecule. In contrast to H₂, NH₃ presents an impressive volumetric energy content: 12.69 MJ/L in the cooled liquified form, and 11.65 MJ/L if liquefied by compression. In addition, its liquefaction requires mild conditions (~33°C at 1 bar and ~10 bar at 25°C) compared to H₂, substantially reducing storage and transportation requirements. Ammonia can be produced by renewable energy sources (RES) and it has an established storage and distribution infrastructure, as the

2nd most produced chemical worldwide. These facts showcase the massive potential of NH₃ to complement, if not overtake, H₂ as the leading alternative fuel. It's readily available, we know how to handle it safely and through consistent R&D we believe we can make it combust efficiently and with ultra-low emissions.

What are the key challenges in stabilising ammonia combustion, and how does plasma specifically help to overcome them?

Ammonia combustion suffers from severe challenges not only on the stabilisation of ammonia flames but also on the production of NO_x. Its combustion properties show short flammability limits, poor ignition quality, low laminar flame speeds and high minimum ignition energy. Moreover, NH₃ presents substantially high latent heat of vaporisation which hampers direct liquid phase combustion and reduces overall efficiency. Most importantly, NH₃ oxidation produces significant NO_x emissions.

Plasmas have demonstrated capabilities for enhanced ignition, flame stabilisation and byproduct reduction in various

combustion mixtures and processes. Non-equilibrium plasmas offer three main combustion enhancement mechanisms: a) Thermal mechanism owed to e.g. Joule heating, V-T relaxation, and ultrafast gas heating. b) Kinetic mechanism through electron impact reactions and consequent secondary ion and neutral ones. c) Transport mechanism through momentum transfer to heavy species.

CAIPIRINH₃A will leverage all these mechanisms of non-equilibrium plasmas, developing dedicated and well characterised plasma sources, which in conjunction with advanced liquid fuel injectors and smart control strategies for the suppression of instabilities, will enable us to overcome the aforementioned challenges and achieve high combustion performance with ultra-low NO_x emissions.

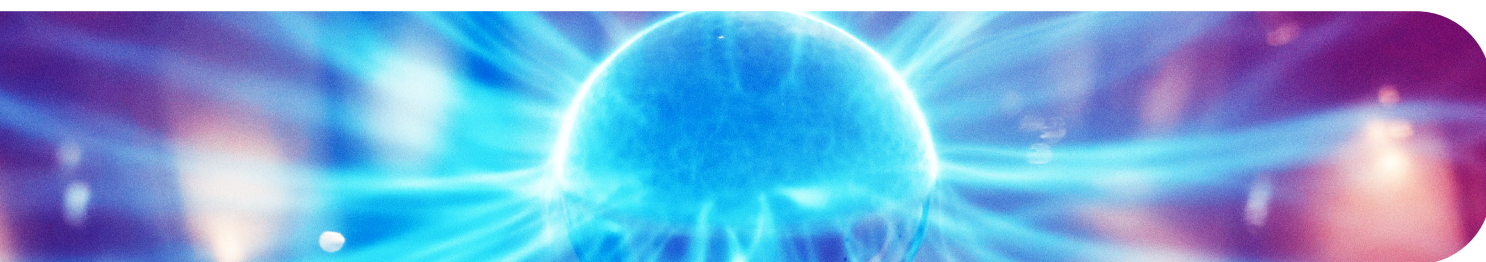
When do you expect the first results, and what is the long-term vision for CAIPIRINH₃A technologies?

We are delighted to have already produced 8 scientific publications – before even completing the 1st year of our project. The CAIPIRINH₃A consortium

is very multidisciplinary and highly committed to excellence, we thus expect to produce more exciting results in the following years on aspects related to: ammonia and plasma kinetics, innovative plasma sources adapted to ammonia environments, novel liquid ammonia injection systems, multiscale and Multiphysics simulations, active control of combustion instabilities, mixing and swirling.

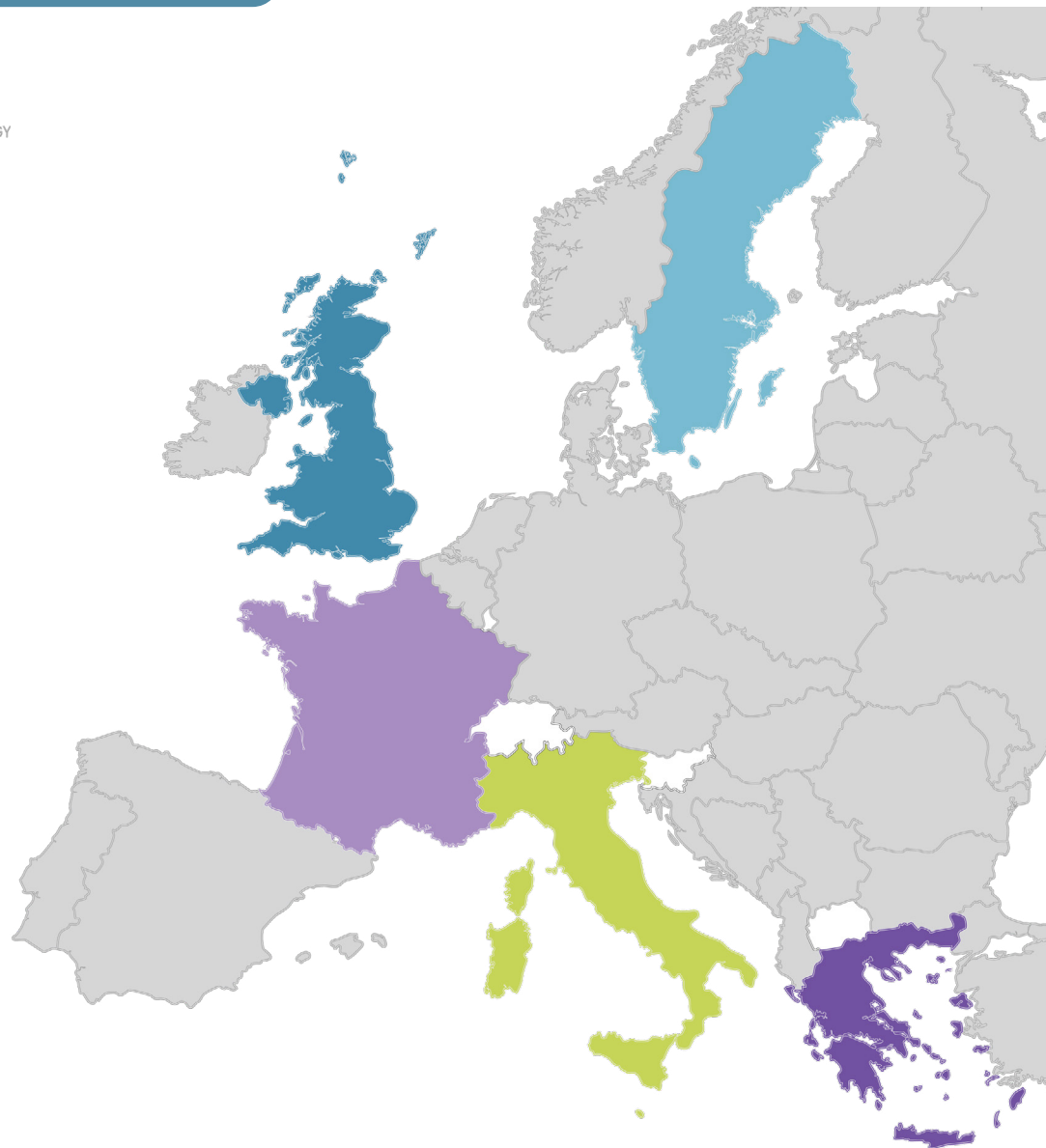
The combination of the above, will allow us to meet our main objective: to build, test and evaluate in the laboratory, a novel plasma-assisted ammonia combustion setup, the Plasma Mist Ammonia (PlasMi-NH₃) burner.

The demonstration of our technology will boost NH₃ innovation capacity to drive growth, profitability, and the transition to a sustainable alternative fuel economy. The holistic evaluation of our results will increase public acceptance of NH₃ as a fuel, showcasing the long-term potential to create quality jobs, combat climate change and strengthen EU energy security, fostering a self-reliant and resilient energy future.



PARTNERS

CAIPIRINH₃A CONSORTIUM



CAIPIRINH₃A brings together a unique cocktail of scientists, end-users, and consultants to unlock ammonia's true potential as a fuel. The project is developing a first-of-its-kind ammonia combustor that leverages plasma technology to minimise NO_x emissions and ammonia slip, without the need for additional pre- or post-treatment systems.

ACTIONS

1st YEAR OF PROJECT

12th European Combustion Meeting (ECM-2025)

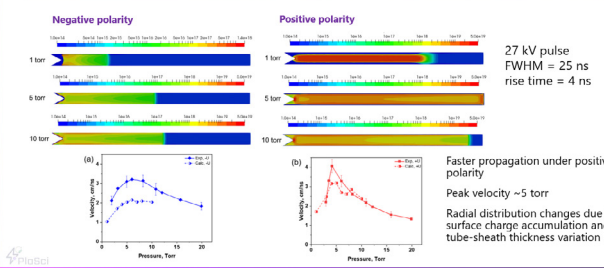
7th-10th April 2025 Edinburgh, Scotland, UK

CARDIFF University took part in the **12th European Combustion Meeting (ECM-2025)** in Edinburgh, Scotland. Representing the team of Centre of Excellence on Ammonia Technologies (CEAT), Dr. Aravind Balakrishnan and Mr. Ziyu Wang showcased their innovative work on through two distinctive posters.



- o "Novel strategy for combustion enhancement of NH₃-air mixture using gliding arc plasma"
- o "Numerical investigation on the combustion characteristics of premixed NH₃-air flames using gliding arc plasma"

NANOSECOND PULSED FAST IONIZATION WAVE



French Cold Plasma Network Seminar

23th May 2025, Paris, France

Dr. Konstantinos Kourtzanidis from ARTEMIS Laboratory of CPERI/CERTH, delivered an Invited Seminar as part of the **French Cold Plasma Network (Reseau Plasma Froid) series**, at the Laboratory of Process and Materials Sciences (LSPM CNRS UPR 3407 – Université Sorbonne Paris Nord). The seminar was entitled: "Understanding Plasma Dynamics through Multi-Dimensional Modeling: Significance, Challenges and Prospects Beyond Global Models".

The seminar was attended (physically and on-line) by students, researchers and academics from several countries. Plasma modeling is a core aspect of CAIPIRINH₃A project towards a fundamental understanding of plasma dynamics and eventually combustion effects. During his seminar, Dr. Kourtzanidis included a one-slide overview of CAIPIRINH₃A project.

International Symposium of ElectroHydroDynamics (ISEHD 2025)

10th-13th June 2025 Seville, Spain

CERTH participated in the [International Symposium of ElectroHydroDynamics \(ISEHD 2025\)](#) in Seville, Spain. Dr. Konstantinos Kourtzanidis had the opportunity to present a collaborative work entitled: "Aerosol Jet Printed Surface Dielectric Barrier Discharge (AJP-SDBD) Plasma Actuators: Fabrication and Electromechanical Characteristics".

The presentation demonstrated the applicability of AJP for fabricating Surface Dielectric Barrier Discharges (SDBDs) of ultra-fine electrode contouring and unconventional shaping by characterising various designs in terms of plasma and induced flow (ionic wind) properties. SDBDs will be used in CAIPIRINH₃A as means of active flow control devices for enhanced mixing. During the technical presentation, Dr. Kourtzanidis included a one-slide overview of CAIPIRINH₃A project and afterwards, shared hard copies of CAIPIRINH₃A's flyer to interested participants.

This work was a collaborative effort between CERTH team (funded by CAIPIRINH₃A project), and external partners: Delft University of Technology (Netherlands), LSPM-CNRS (France) and Aristotle University of Thessaloniki (Greece).



International Flame Research Foundation (IFRF) conference

17th -19th June 2025 Sheffield, England

Cardiff University participated in the [International Flame Research Foundation \(IFRF\) conference](#), "Sustainable and Safe Industrial Combustion," which brought together experts from a wide range of industrial sectors, including power generation, refining, petrochemicals, and oil and gas. During his presentation, Dr. Agustin Valera-Medina introduced the CAIPIRINH₃A project, showcasing current work on plasma technologies. His talk sparked lively discussions, particularly on the efficiency of using high-voltage plasma generators to enhance ammonia combustion, a concept that will be further explored in CAIPIRINH₃A's ongoing research.



International Conference on Phenomena in Ionized Gases 36th Edition

20th-25th July 2025 Aix en Provence, France

Dr. Svetlana Starikovskaia from CNRS presented "Measurements of G-value at high electric fields in pulsed nanosecond

discharge" at the [International Conference on Phenomena in Ionized Gases \(ICPIG\)](#). Since 1953, ICPIG has been a key forum for plasma science, spanning fundamentals to applications such as medicine, combustion, and environmental protection. Her talk introduced a novel experimental method to measure species production efficiency in nanosecond pulsed plasma. Developed at the Laboratoire de Physique des Plasmas (LPP) and tested on nitrogen, this approach will be extended in 2025-2026 with Lund University using NH₃ in the CAIPIRINH₃A project.

CAIPIRINH₃A

Combustion of liquid ammonia, assisted by plasma discharges, as a novel and clean energy conversion method

Concept

Developing the next generation smart combustor: Plasma Assisted Liquid Ammonia Burner



Methodology

Experimentally validated kinetic and plasma modelling, computational fluid dynamics and combustion simulations to fabricate:

- An efficient L-NH₃ injection system
- Tailored ns pulsed plasma systems **including AC-SDBD actuators for enhanced mixing & combustion control**
- Combustion rig & demonstrator reaching TRL 4

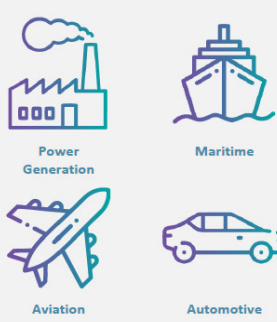
Holistic Approach to ensure environmental, social, economic sustainability:

- LCA, LCC, sLCA
- Market research & uptake strategies

Benefits

- No Greenhouse gases, harmful pollutants or toxic fumes
- Minimum NO_x emission
- Almost zero NH₃ slip
- Reduced noise levels

Sectors of Interest





International Combustion Institute Winter School (CI-WS2025)

20th – 25th July Campinas, Brazil

Dr. Agustin Valera-Medina from Cardiff University was a keynote speaker at the [10th International Combustion Institute Winter School](#). With more than 250 attendees, the event proved to be the right place to disseminate the topic of Ammonia Energy. Dr. Agustin presented ammonia's benefits as an emerging carbon-free fuel to support decarbonisation. His talk highlighted ongoing research advancing its use in turbines, engines, and boilers to overcome efficiency and emission challenges, with part of the presentation dedicated to CAIPIRINH₃A's research and vision.

SIYUAN Forum Plenary

6th September 2025 Shanghai, China

CAIPIRINH₃A was proudly introduced at the [SIYUAN Forum Plenary](#) hosted by Shanghai Jiao Tong Universit. in Dr. Agustín Valera-Medina (Cardiff University) delivered an insightful presentation titled "Ammonia for Power" sparking strong interest in CAIPIRINH₃A's mission. His talk highlighted ammonia as a carbon-free energy carrier with higher energy density than compressed hydrogen and an established transport network, making it a practical next-generation system for energy storage and power generation.



International Conference on Research & Application of Plasmas, PLASMA 2025

15th -19th September 2025 Warsaw, Poland

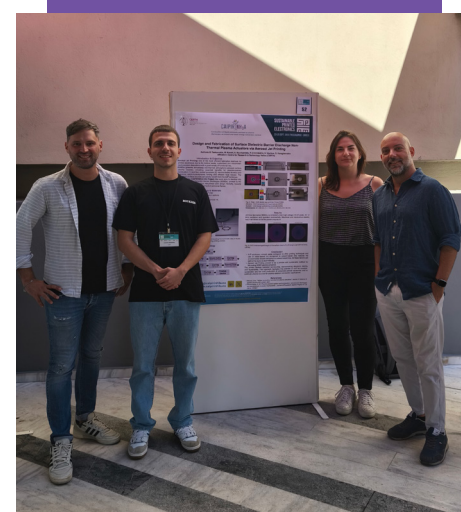
CNRS participated in [PLASMA 2025](#) in Warsaw, Poland, a conference held under the honorary patronage of the Minister of Science and Higher Education. Svetlana Vankova presented her poster "Measurement of Energy in Nanosecond-Scale Plasma," providing an excellent opportunity to showcase CAIPIRINH₃A's research and capabilities while engaging with scientists and engineers across Eastern Europe in the field of plasma physics and technology.



Sustainable Printed Electronics Conference SPE2025

23rd-25th September 2025 Thessaloniki, Greece

The Artemis Laboratory of CERTH participated in [SPE2025](#) conference with a poster showcasing their efficient methodology for the fabrication of SDBD actuators titled "Design and Fabrication of Surface Dielectric Barrier Discharge Non-Thermal Plasma Actuators via Aerosol Jet Printing" complemented with an oral presentation "Aerosol Jet Printing: Technique Overview and Proof-of-Concept Demonstrations in Additive Manufacturing".



During this event, the ARTEMIS team received the First Prize Poster Award, further demonstrating the excellence and rigor of their research and methodological approaches.



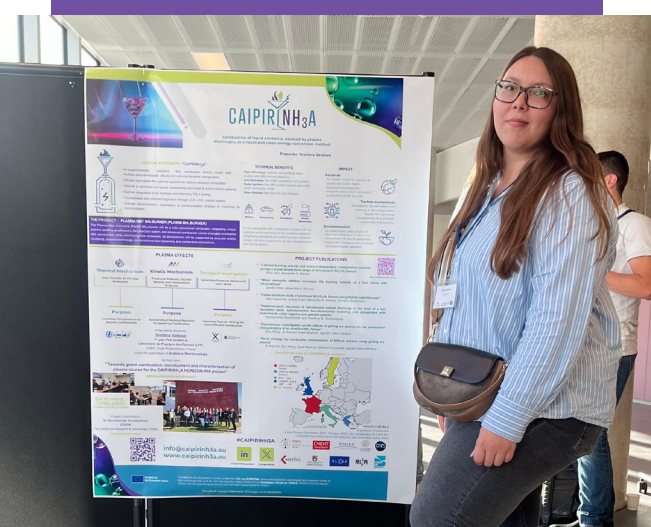


Researchers' Night 2025

26th September Athens, Greece

EXELISIS participated in **Researchers' Night** at the National University of Athens, Greece, with an engaging booth where CAIPIRINH₃A was introduced to young students and children interested in the field of energy.

To inspire them, EXELISIS had designed and distributed a special flyer for young researchers, featuring vivid, eye-catching colors to capture their attention.

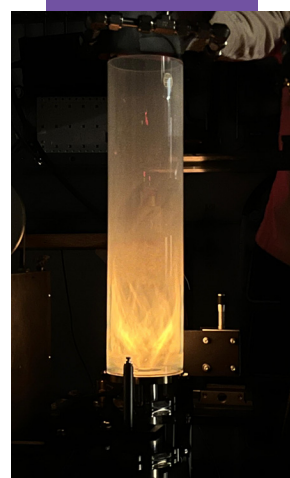


International Symposium on Plasma-Assisted Combustion (SOPAC)

29th September-1st October 2025 Gif-sur-Yvette, France

CNRS was one of the co-organisers of **SOPAC**, held at Centrale Supélec of Université Paris-Saclay in Gif-sur-Yvette, France.

The symposium provided plasma-assisted combustion researchers with a unique forum to share their latest work, identify knowledge gaps, and foster collaborative research in areas such as flame stabilisation, thermoacoustic instability control, pollutant emission reduction, ignition enhancement, supersonic combustion, diagnostics, kinetics, and numerical modelling. Svetlana Vankova, together with Professor Svetlana Starikovskaia, engaged in insightful discussions with fellow researchers, showcasing CAIPIRINH₃A's innovative concept.



Advancing Low-Carbon Solutions for a Net-Zero Future, British Flame

1st -2nd October 2025 Poole, United Kingdom

Dr. Aravind Balakrishnan from CARDIFF University presented their innovative work on plasma-assisted ammonia combustion, carried out within the CAIPIRINH₃A project, at the **British Flame Meeting**. The event hosted at RNLI College in Poole, provided an excellent platform for professionals from diverse fields to exchange research insights and discuss progress, challenges, and requirements for advancing industrial combustion towards greater efficiency and safety.



4th Symposium on Ammonia Energy (SOAE)

28th September-2nd October 2025 Minesota, United States of America

Cardiff University co-organised the **4th Symposium on Ammonia Energy (SOAE)** in the USA, a globally recognised forum addressing challenges in ammonia production, storage, transportation, utilisation, and safety. Dr. Agustin Valera-Medina presented research on boilers and novel plasma-assisted concepts to enhance ammonia combustion, highlighting CAIPIRINH₃A's early findings and future directions. The talk drew strong interest from experts from Japan, South Korea, and North America, and attracted potential partners, creating an excellent opportunity to strengthen CAIPIRINH₃A's global outreach.



KNOWLEDGE REPOSITORY

zenodo

A dedicated Zenodo community has been created to bring all CAIPIRINH₃A research together on one platform. The first series of published research is showcased below, featuring seven publications currently available, with many more on the way.

You can explore them directly on [Zenodo](#) or through our [Website](#).

Journal: Combustion & Flame

Laminar burning velocity and unburnt temperature: Comparative analysis across a broad temperature range of atmospheric NH₃ + H₂ flames

Journal: Combustion & Flame

When ammonia addition increases the burning velocity of a fuel blend with nitromethane

Journal: Combustion & Flame

Flame structure study of premixed NH₃ / O₂ / Ar flames using Raman spectroscopy

Journal: Plasma Sources Science and Technology

2D imaging of atomic oxygen reaction dynamics after a nanosecond pulse discharge using Light-field Amplitude Control

Journal: Applied Physics

Spatiotemporal dynamics of nanosecond pulsed discharge in the form of a fast ionization wave: self-consistent two-dimensional modeling and comparison with experiments under negative and positive polarity

Journal: Energy

Experimental investigation on the effects of gliding arc plasma on the combustion characteristics of air stratified NH₃ flames

Journal: Proceedings of the Combustion Institute

Novel strategy for combustion enhancement of NH₃-air mixture using gliding arc plasma

Journal: Combustion & Flame

Numerical investigation on the combustion characteristics of premixed NH₃-air flames using gliding arc plasma



NEXT STEPS

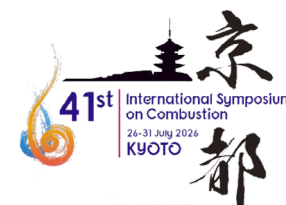
UPCOMING EVENTS



Low Carbon Combustion Meeting

March 2026

Southampton, United Kingdom



41st Symposium of the Combustion Institute

July 2026

Kyoto, Japan



5th Symposium on Ammonia Energy

September 2026

Santiago, Chile

EAC 2026

European Ammonia Conference 2026

October 2026

Düsseldorf, Germany



MATERIALS

DISSEMINATION CORNER

You can find printable materials in website's "Digital Toolkit" where you can download them and use them to disseminate the project.



[CHECK ALL MATERIALS HERE](#)

Find our Press Releases and Newsletters for the latest Project Updates

[HAVE A LOOK](#)



Plasma Assisted Liquid-Ammonia combustion, the future of energy and mobility sectors



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