Acadamh Ríoga na hÉireann
Royal Irish Academy

RIA-RSE Cost share grant report

Recipient name:	Professor Paula Bourke
Amount and year awarded:	€7,400 in 2018
Title of project:	MicroPlas: Understanding Cold Plasma control of Biofilms

Summary of findings:

The MicroPlas project had an ambitious sequence of scientific aims, ranging from exploiting the synergy and the collaboration across the partners, to understand gaseous and liquid mediated cold plasma effectors and their importance in biofilm interactions.

Despite the negative impacts of Covid 19 pandemic, the key achievements were fourfold:

1. People - each PI and team had the opportunity for reciprocal explorative and preparatory visits, building networks across the broader teams that persist, with collaborative research proposals underway

2. Infrastructure, expertise and equipment were shared across each team, with early stage researcher (Singwei Ng - Bourke Team) bringing plasma system to Walsh team for a month long research stage, to learn and utilise Walsh team equipment and expertise to characterise and understand the plasma discharge and quantify the principle plasma reactive species.

3. A combined publication was developed from this collaborative work, written over 2020 and 2021, and which was then accepted for publication in 2021.

Singwei Ng, Elmar Slikboer, Aaron Dickenson3, James L. Walsh, Peng Lu, Daniela Boehm, and Paula Bourke. Characterization of an atmospheric pressure air plasma device under different modes of operation and their impact on the liquid chemistry. Journal of Applied Physics 129, 123303 (2021); https://doi.org/10.1063/5.0039171

4. Post-doctoral researcher (Dr Breno Salgado) from Walshe Team visited Bourke lab for February 2022, where the scientific aims of understanding biofilm interactions with cold plasma were progressed. Dr Breno Salgado received training in AFM analysis of Biofilms as well as 3D Bioprinting of biopolymers and integration of biofilm forming cells to printable and controllable matrices. This work is forming the basis for a Marie Curie application with Dr Salgado.

The impact of this work is; increased understanding of the plasma system, the plasma discharge and the principle plasma reactive species, and how their effects can be assessed in biopolymers of clinical relevance.

Images to date are too large to upload here but can be provided separately, Snip provided is adapted from figure within Journal of Applied physics publication.

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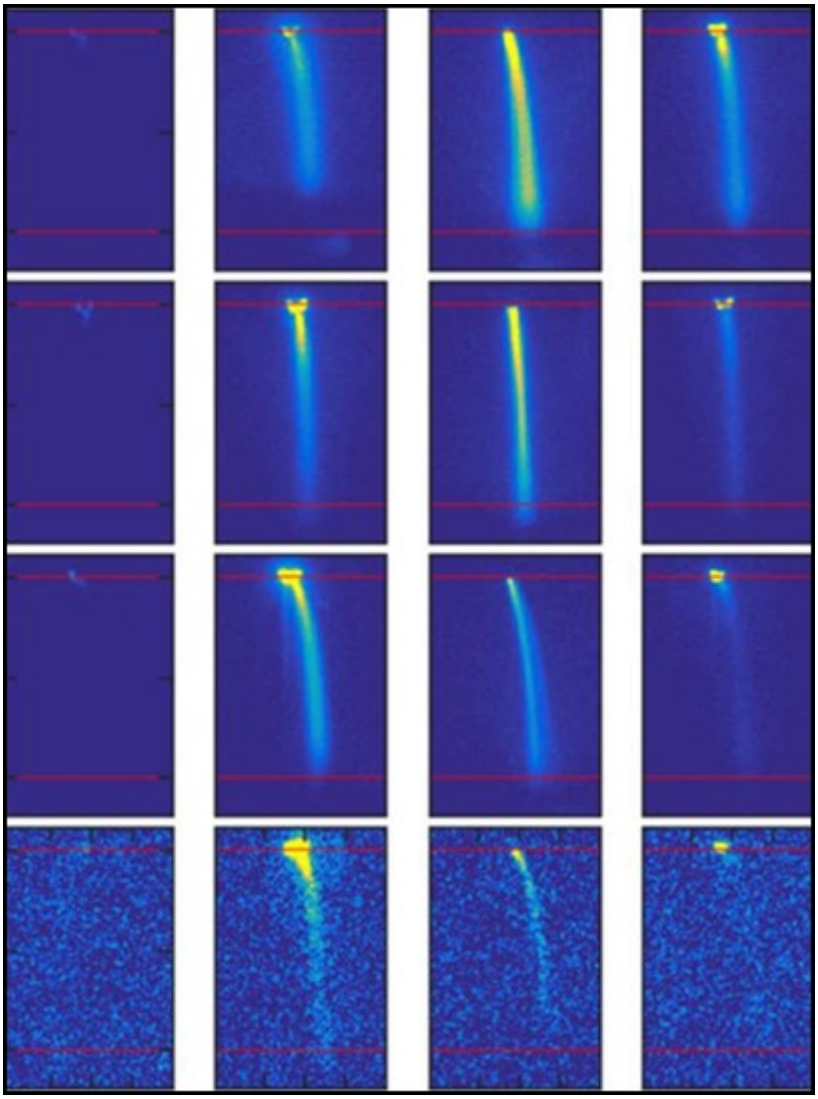

Travel undertaken and institutions visited:

Professor Bourke travelled to University of Liverpool - 2019

Professor Walshe travelled to TU Dublin - 2019

Professor Walshe team travelled to TU Dublin - 2019

Mr Singwei travelled to University of Liverpool - 2020 (Feb)

Dr Breno Salgado travelled to TU Dublin and University College Dublin (2022)

Outline the research activities undertaken:

The main research activities were built from the respective PI and researcher exchange visits and online and in person meetings.

Initially, based on the successful demonstration of the RSS system to generate plasma functionalised liquids with potent effects on biofilms, the decision was made to prioritise mechanistic understanding of the RSS spark and glow configurations.

The chemical composition of PAW generated by both configurations was examined by colorimetric measurement and UV–Vis absorption spectroscopy.

To further understand the discharge propagation mechanism in each configuration, time-, space-, and wavelength-resolved imaging was performed. Using narrow bandpass filters at 310, 340, 390, and 780 nm, the emission from excited OH, N2 (SPS, second positive system), N2+ (FNS, first negative system), and atomic O, respectively, were captured.

The optical and electrical measurements were used to explain the result of the colorimetric tests and tentatively identify the link between the configuration of the plasma system and the generation of H2O2 in the bulk liquid.

When lab-based activities for visits were feasible again, the return trip for University of Liverpool researcher to the Bourke lab was focused on characterising the Plasma functionalised liquid interactions with Staphylococcus aureus USA300. Training was provided on Atomic Force Microscopy analysis with the Rodriguez Lab in UCD, and the 3d Bioprinter in the Bourke lab. The control preformed Biofilms were assessed using AFM for comparison with Biofilms treated with Plasma functionalised liquids. Alginate was used for biofilm model dot prints and the survival of Staphylococcus aureus within printed alginate dots as assessed. Microbiological tests are ongoing in Bourke lab to work towards a further collaborative publication and a post-doctoral Marie Curie application.

Published work and publication plans:

One collaborative article published to date in prestigious applied Physics Journal

Singwei Ng, Elmar Slikboer, Aaron Dickenson3, James L. Walsh, Peng Lu, Daniela Boehm, and Paula Bourke. Characterization of an atmospheric pressure air plasma device under different modes of operation and their impact on the liquid chemistry. Journal of Applied Physics 129, 123303 (2021); https://doi.org/10.1063/5.0039171. Further collaborative publication on AFM and Biofilm printing planned on completion of ongoing studies.

Dissemination and plans for future dissemination:

Local events at each visit, online cross team event in 2021

Work on system characterisation was included in submission at ICPM 8, 2021

Oral presentation by Mr Singwei Ng, to International Conference on PLasma Medicine, August 3-6, 2021, Online Conference, Korea.

Collaborations and planned collaborations:

Additional collaborations with national partners

Professor Brian Rodriguez, UCD AFM analysis

Additional collaborations with international partners

Professor Theresa Freeman, Jefferson University, USA

Professor Tom Schaer, UPenn, USA

Professor Noreen Hickok, Jefferson University, USA

Professor Brendan Gilmore, Queens University Belfast, UK

Professor Paul Maguire, University of Ulster, UK

The national and international collaborations are focused on understanding plasma functionalised liquids and their potential as a therapy for biofilms associated with bone infections. The insights from the orthopedic surgeon team in the US universities provides the rationale for floating biofilm and dispersive infection model development using the 3D Bioprinter approach.

Additional collaborations with Industry

Terraplasma - Germany

Apyx Medical - USA

These industry collaborations provide plasma medical devices approved for clinical use, which we investigate in combination with plasma functionalized liquids for infection control.

Outreach and engagement activities:

Public and schools based engagement activities have been developed and were designed for in-person delivery to festivals and events such as Airfield, SciCom and transition year visits to University labs.

A specific activity on communication regarding infections and plasma as a novel therapy is underway.