Report on the outcomes of a Virtual Mobility[1]

Action number: CA19110

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Virtual Mobility Details

Title: "Report on the efficiency of available CAP sources used for liquid treatment"

Start and end date: 07/10/2022 to 21/10/2022

Description of the work carried out during the VM

This project is about Cold Atmospheric Pressure (CAP) devices (such as Corona, Corona/DBD-jet, DBD-rod, DBD, etc) used for liquids or water plasma treatments (PAL and PAW). The aim of this project is to investigate the technological development of CAP devices used for liquid treatment and evaluate their effectiveness based on the Reactive Oxygen and Nitrogen Species (RONS) absorbed by the liquid during treatment. This project starts with a review of the scientific literature for the last 3 years. The literature search was done using the tools SCOPUS (website platform) by selecting the following research criteria as input:

- Plasma AND (cold OR atmospheric) AND (liquid OR water).

The selected sources were:

- Articles;
- Journals;
- Book chapter.

Then, I downloaded the extracted records to a CVS file and reported them on Excel table. Several pre-processing methods were applied to improve the quality of the collected data such as:

- Deletions of records that did not report enough data, e.g. articles about PAW that do not report the value of all long-life RONS concentration;
- Deletions of records that did not report plasma treatment details or articles about low pressure plasma treatments;
- Deletion of records with no results in terms of RONS produced;
- Detection of any duplicates;

The choice of the most interesting data to extrapolate was made through collaboration with experts in the field and with members of CA1910 with whom I consulted before extrapolation, the extrapolated data were:

[1] This report is submitted by the grantee to the Action MC for approval and for claiming payment of the awarded grant. The Grant Awarding Coordinator coordinates the evaluation of this report on behalf of the Action MC and instructs the GH for payment of the Grant.

- Type and volume/flow rate of liquid and carrier gas;
- Concentration of RONS;
- pH and conductibility;
- Operating conditions (kV, A, W);
- Type of CAP used.

Once the extrapolation process was finished, I proceeded to analyze the data, with statistical rework to figure out :

- CAPs device most used;
- Liquid or carrier gas most used;
- RONS average absorbed;
- Average treated liquid volume;
- Average pH value reached at the end of the treatments.

Once the statistical surveys were done, I analyzed the collected data, investigating the link between the CAP source used and RONS absorbed trying to understand if some CAP device is more efficient than others in the production of a specific RONS. Once I found the most commonly used sources, I described the geometric features by investigating the most common used materials and structural choices. The results explained in the final report will be available to all PlAgri members in the form of graphs (see the attached file) and a brief description of geometrical structure and materials used for the most common CAP (Corona, DBD and DBD-jet). In order to improve the sharing and distribution of the report, I have made 1 instructional video, where I briefly explain the guidelines of the scientific research and the results extrapolated from the analysis. Then I describe the CAP sources for PAW used within the laboratories of the Industrial Applications of Plasmas (AIP) group of the Department of Industrial Engineering, University of Bologna. To improve even more the collaboration within PlAgri I have sent an email to all participating members asking for their contribution by making a short video where they present the CAP devices for PAW used within their laboratories. All contributions are merged into one final video that will share on the various PlAgri online platforms.

Description of the VM main achievements and planned follow-up activities

The literature scientific research study led to the extrapolation of 2560 data points. The first step was to find out which types of liquid (Deionised, Distilled, Reverse Osmosis and Tap Water), carrier gas (Air, Ar,He,N_2,O_2) and CAPs (Corona, Corona/DBD-jet, DBD-rod, DBD, etc) were most commonly used during PAW treatments. The data extrapolated during this first step were reported in the form of a cake graphs. The second step deals with the evaluation of the efficiency of the PAW treatments based on the RONS produced. To achieve these objectives, I extrapolated the data of the RONS (H_2O_2,NO_2 ,NO_3) based on the type of liquid, the type of carrier gas and depending on the chosen CAP source. The outputs of this extrapolation are three graphs, one for each long-live RONS where it can be read the average concentrations of RONS based on the type of liquid, gas or CAP source used; together with the average concentrations of each RONS I have reported the standard deviation and the maximum and minimum value extrapolated by data from each articles . In addition to the graphical outputs of the produced RONS, I extrapolated the data of average treated volume and pH (with standard deviation and maximum, minimum value extrapolated by data from each articles) reached by the liquid at the end of the treatment and graphed them in the usual way as the produced RONS were reported.

Scientific literature shows that the effectiveness of cold plasma treatment (not only for PAW) is based on the production of short- and long-lived RONS. Therefore, a more in-depth knowledge of the concentrations of RONS and the possibility of control their production would lead to a more thorough understanding of the effectiveness of cold plasma treatments, facilitating future developments of this technology. This report is intended to be a simple guide to understand the effectiveness of PAW treatments and what are the most common choose to approach a plasma liquid treatments. The results provide important and useful data that will be used when composing a review paper related to this topic as well as to provide information about current research stage.

The first development of this project could be to implement data collection by going further back in time with the selected articles and extrapolating data also from reviews and not only from articles and book chapters. Further

development will be related to the analysis of the production of the reactive species based on the pH reached at the end of the treatment or to investigate the influence of the treatment time on these processes in order to analyze the production rate of RONS.