

# Influence of the liquid target on the electric field strength in helium plasma jet

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# INFLUENCE OF THE LIQUID TARGET ON THE ELECTRIC FIELD STRENGTH IN HELIUM PLASMA JET

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**Abstract.** In this paper we present electric field distribution in He plasma jet impinging the surface of different liquids. Dielectric barrier discharge (DBD) plasma jet with constant He flow of 1000 SCCM, operating at applied voltage of 2 kV and 30 kHz, was positioned above the liquid surface. Electric field measurement was performed using Stark polarization spectroscopy when Petri dish with distilled water or physiological saline (0.85 % NaCl) was positioned 10 mm below the plasma jet nozzle. Obtained axial distributions of the electric field show that maximal values of the field are similar for different targets.

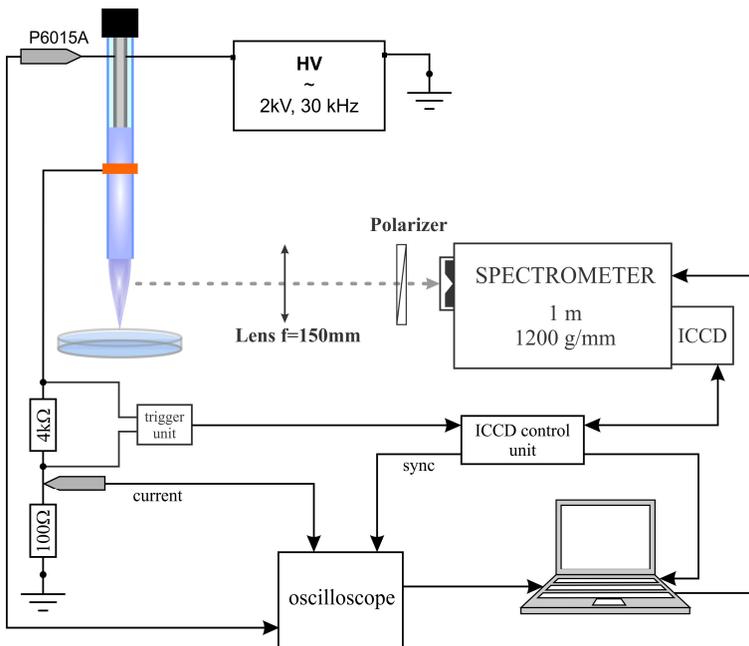
## 1. INTRODUCTION

In recent years atmospheric pressure plasma jets have been extensively investigated and recognized as an emerging tool in the field of plasma medicine and biology [1]. Plasma jets are source of reactive oxygen and reactive nitrogen species which play important role in redox biology and medical applications [2]. Among reactive species, it is known that electric field can be the cause of various effects observed in experiments on biological samples [3] and it determines the production of charged particles, consequently the plasma chemistry, which can play a very significant role in the rupture of the outer membrane of bacterial cells [4]. In our previous study of spatio-temporal development of the plasma jet in helium for two different electrode configurations it was found that without the grounded electrode downstream from the nozzle the maximal value of electric field was about 10 kV/cm. Contrarily, when a grounded electrode is present, a maximal electric field of 20 kV/cm is obtained [5]. This suggests great influence of target on jet properties, especially in plasma medicine cells in tissue or in in vitro experiments are surrounded by liquid, thus plasma-liquid interaction is important to understand the plasma-cell interaction and design of the most favorable experimental conditions. The aim of this study was to investigate the

influence of the liquid targets on the electric field strength in helium plasma jet. Namely, distilled water and NaCl solution, positioned downstream the jet, were selected as test liquids since these are most commonly used in research of interaction of plasma with biological samples.

## 2. EXPERIMENT

In this study, we present our recent research on helium plasma jet interacting with the liquid surface. Here we focus on spatially resolved measurements of the electric field strength along the jet axis when water is positioned below the jet nozzle as a target. The atmospheric pressure plasma jet in use has already been described in detail elsewhere [6, 7]. Powered electrode is needle with the inner diameter of 0.8 mm centered inside the Pyrex capillary (inner diameter 2.5 mm, outer diameter 4 mm). Metal ring on the outer side of the capillary is used as the grounded electrode. The thickness of the ground was 3 mm, and the gap between the two electrodes was 5 mm, while the distance from the grounded electrode to the end of capillary was 20 mm. Helium flow was set to 1000 SCCM by mass flow controller. The power supply provided a sine voltage at 2 kV in amplitude and 30 kHz frequency. Liquid samples were set in a Petri dish and a constant distance between jet nozzle and liquid surface of 10 mm was adjusted.

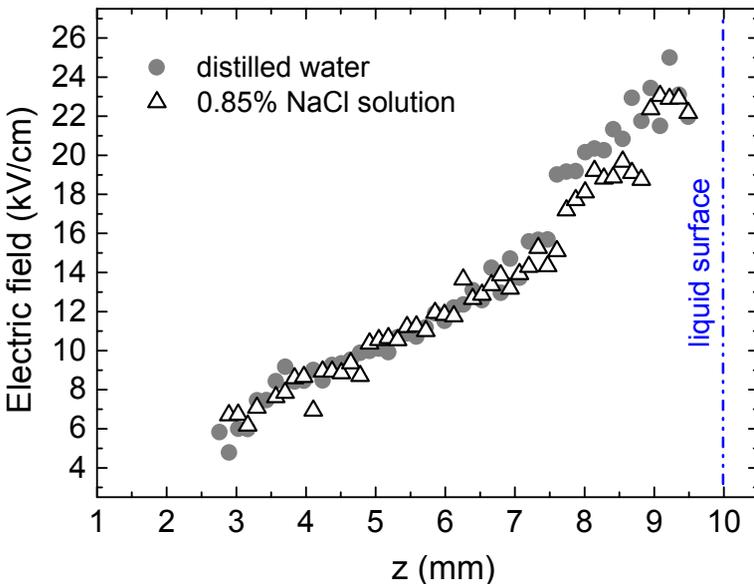


**Figure 1.** The schematic overview of the experimental setup.

Distilled water and physiological saline (NaCl solution 0.85%, 8.5g NaCl per 1000ml water) were used as targets. Electric field strength was measured by non-perturbing method based on Stark effect of helium lines developed by Kuraica and Konjević [8], and it was already applied for the electric field measurements in He plasma jets [5,9,10].

### 3. RESULTS

The electric field measurements are presented in Fig. 2. Figure 2 shows the distribution of the electric field along the plasma plume when it contacts distilled water or physiological saline. It is clear that measured electric field rises with the distance from the capillary reaching the maximum value of about 25 kV/cm when distilled water was treated. When plasma jet operates without target, measured electric field strength at 9 mm from the exit of the capillary was about 18 kV/cm. Also, if distilled water is positioned at 5 mm from the capillary exit maximal value of the electric field will reach 20 kV/cm (results are not shown here). Spatial development of the electric field along the jet axis for two liquids almost overlap, with slight increase of the electric field strength in the vicinity of the liquid surface when distilled water was target. One should have in mind that initial conductivity of distilled water was 2.5  $\mu$ S/cm while that of physiological saline was 14.94 mS/cm.



**Figure 2.** Electric field strength in the plume of the plasma jet when distilled water and NaCl solution were positioned 10 mm from the exit of capillary.

The results suggest that the type of the treated solution does not influence considerably axial distribution of the electric field strength nor its magnitude. Such conclusion is significant for research in the field of plasma medicine where interaction of plasma and biological sample occurs through different liquids. Our recent research implies that discharge configuration crucially affects the properties of the plasma plume and influence of different targets will be further investigated.

## Acknowledgements

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