Electrical and optical diagnostics of PCC DBD plasma source

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Abstract: The main features of the Plasma Coagulation Controller (PCC) device are presented. PCC is a cold atmospheric pressure plasma source based on the Dielectric Barrier Discharge (DBD) scheme, specifically designed for accelerating blood coagulation. Electrical, thermal, spectroscopic and fast camera measurements are provided to characterize the physical and chemical features of PCC.

Keywords: plasma medicine, blood coagulation, plasma diagnostic

1. Introduction

Plasma medicine is an emergent discipline dealing with the study of the therapeutic effects obtained by the treatment of living tissues through the application of cold atmospheric plasmas. Several applications have been proposed in the last years, including disinfection, blood coagulation, wound healing and cancer cell treatment [REF]. Despite the widespread opinion that the agents responsible for the action on biological tissues are the reactive species produced in the ionization process such as the Reactive Oxygen and Nitrogen Species (RONS), the mechanisms of this action are not yet fully understood. Therefore a chemical-physical characterization of cold plasmas, associated with the study of biological processes occurring in the treated substrate, is mandatory.

In this contribution, a characterization of a plasma source, specifically designed for blood coagulation (PCC), is presented by describing electrical and optical measurements.

2. PCC: Plasma coagulation controller

PCC[1,2] device is a source of atmospheric cold plasma based on the concept of DBD. It consists of two main parts: a control box, which contains the main power supply and a control circuit, and a source head, in which the plasma is produced, containing the voltage elevation circuit. A gas (helium or argon), flowing through the source head, is ionized by the application of high voltage pulses between two electrodes separated by a borosilicate glass tube, which acts as a dielectric. The high voltage pulse control, carried out by means of an Arduino microcontroller, can be managed by varying independently both the voltage and repetition rate. . This makes the PCC a very flexible plasma source, suitable for the study of plasmas in different conditions.

3. Measurements

In order to electrically characterize the PCC, the voltages at the biased electrode as well as the current induced by plasma on a metallic target have been determined. Voltage measurements were performed by means of a high voltage probe Tektronix P6015A, while current measurements were performed on a metal target using a current probe TEK CT-2. The latter has shown an effective current value of a few mA, hence PCC plasma is suitable for direct application on human tissues.

The light emission of PCC plasma has been studied by optical emission spectroscopy (PI spectrometer ISOPLANE, PI-PIXIX Camera). The presence of reactive plasma species (RONS) has been highlighted in different operating configurations. In particular, different plasma spectra have been acquired using different working gases (helium, argon), even with the addition of nebulized water and ammonia, and also using helium-argon mixtures in different concentrations. Under all conditions, N_2, N_2^+, O and OH lines have been clearly identified.

Fast camera measurements have been performed to study the plasma plume dynamics, by means of a CCD associated with a gated image intensifier. The high speed images, acquired in the presence of both insulator and metal targets, have shown the formation of an emitting structure, which initially grows around the potential electrode and is subsequently expelled from the source head. This structure, known as plasma bullet[3], is emitted from the plasma head with a velocity in the range 40:80 km/s.

4. References

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