Study of chemical modifications induced by an APPJ on an ultra-pure water target

C. Muja [1], L. Invernizzi[1], F. P. Sainct[1] and Ph. Guillot[1]

[1]*Laboratoire Diagnostics des Plasmas Hors Equilibre (DPHE), Université Toulouse, INU Champollion, Place de Verdun 81012 Albi, France*

Due to the increased oxidizing capacities of non-thermal plasmas, they are good candidates for wastewater chemical decontamination. The aim of this work was to assess the chemical changes produced by the exposure of a liquid to a plasma jet and to evaluate its capacity to decompose complex molecules such as pharmaceuticals. An asymmetric atmospheric pressure plasma jet was used to treat liquid samples and several colorimetric methods were used to assess the concentrations of nitrite, nitrate, ozone and hydrogen peroxide. Finally, samples containing acetaminophen (paracetamol) were exposed to the plasma jet and the concentrations following exposure were measured.

1. Introduction

In the last decades, the behaviour of pharmaceuticals in water cycle, raised concerns in both scientific and public media [1]. These molecules generally enter environment though wastewater, where can have negative effects on the ecosystem. Due to the increased oxidation capacity, non-thermal plasmas can potentially be used as oxidation agent for the treatment of polluted wastewater. The aim of this work was to characterize the chemical changes taking place inside the liquid exposed to plasma, with a special interest on reactive species generation. Finally, the capacity of the plasma jet to degrade pharmaceutical products was estimated using as model molecule the acetaminophen.

2. Material and methods

The experimental setup consists of an asymmetric plasma jet with the grounded electrode located on upper large area of the tube and the high voltage electrode on the narrow zone of the source. The discharge was initiated in a Helium-Oxygen mixture (0.2% O_2) at a flow of 2 l.min^{-1}. The high voltage power supply connected to the electrode provides a 6 kV voltage pulse at a frequency of 20 kHz.

The plasma jet is studied in contact with a liquid surface (Milli-Q water). Colorimetric assays were used to determine the concentrations of nitrate, nitrite, ozone and hydrogen peroxide in the liquid phase.

In order to assess the plasma jet capacity to remove complex molecules from water, several acetaminophen solutions were exposed to plasma. Following the exposure, the acetaminophen concentration was then measured using the Glynn and Kendal colorimetric method [2,3].

3. Results

Figure 1 shows the nitrite concentration as a function of the time of exposition to the plasma jet, for various pulse lengths. For treatment durations ranging from 0 to 5 minutes, the nitrite production is linear for all the pulse lengths tested. In the same time, for pulse lengths ranging from 0.5 µs to 1.5 µs the nitrite production increases with the pulse length but remains stable for 1.5 µs - 2,5 µs pulse lengths.

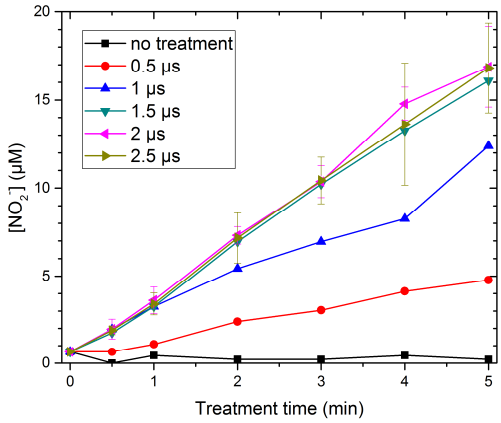

Fig. 1. Nitrite concentration in plasma treated water.

These results as well as the results concerning the other reactive species will be used to discuss the interaction of the plasma jet with the liquid, and the possible mechanisms that leads to the removal of complex molecules from water.

4. References

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[3] Shihana, F., Dissanayake, D.M., Dargan, P.I., Dawson, A.H. Clin Toxicol (Phila) 2010 48(1) 42-46.