How can plasma processes be implemented in food processing?

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Abstract: In this work, the potential use of both Cold Atmospheric Pressure plasmas (CAP) in the field of food processing will be shown, highlighting the pros and cons of these technologies. On one side, the concentration of reactive species produced by plasma and their effect will be analyzed; on the other hand, the induced effect on food matrices will be shown.

Keywords: Plasma treatment, food processing, ozone

1. Introduction

Cold Atmospheric Pressure plasmas (CAP) and Plasma activated water (PAW) have recently drawn considerable attention as a novel non-thermal technology for food product decontamination. Indeed, the emergence of new pathogens contaminating the products and changes of production technologies, consumers' lifestyles and requirements are posing new and peculiar challenges.In this frame, CAP could present several possibilities of high interest. A substantial number of scientific studies appeared in the literature during the last decade, demonstrating the effectiveness of plasma to inactivate degradative enzymes, food pathogens, and spoilage and spore-forming microorganisms, but few focus on the effect on food matrices. Indeed, Before a possible application, many aspects still need clarification, mainly related to consumer safety. The main objective of this project is to provide deeper knowledge about aspects still scarcely investigated about CAP treatment of food products.

2. Materials and Methods

2.1 Plasma system

The plasma system consisted in a surface dielectric barrier discharge (SDBD) plasma source posed on the top of a Plexiglas box to create a closed volume. [1]. The SDBD was air cooled to ensure safety of operation and repeatability of results; the plasma source was connected to a high voltage microsecond pulsed generator. A schematic of the SDBD is reported in Fig.1

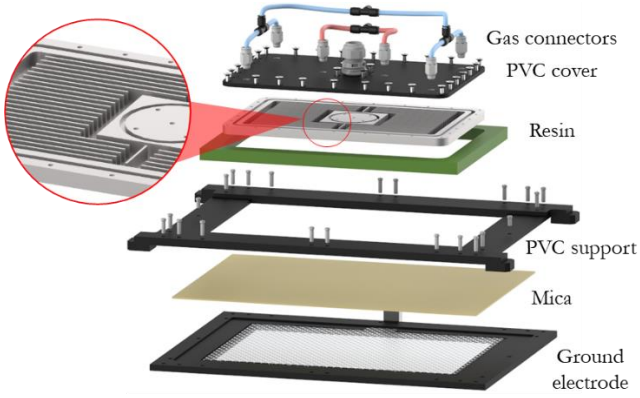

Fig.1 SDBD source

2.2 Plasma treatments

Gas mixtures were obtained using a gas quaternary mixer (mod. KM100-4, Witt-Gasetechnik, Witten, Germany) connected to compressed gas cylinders and a gas-flushing welding machine (mod. Multiple 315, Orved Srl, Venezia, Italy) as following:

- Air: 80% N_2, 20% O_2
- Argon: 80% Argon, 20% O_2
- The treatment chamber was saturated with the gas mixture. Two treatment time were investigated: 10 and 20 min.

2.3.Chemical analysis of gas phase by means of Optical Absorption Spectroscopy (OAS)

OAS was set up according to Simoncelli *et all.* [2]. Briefly, one LEDs was used as light source, operating at 255 nm. The light beam was focused in order to obtain a parallel beam under the mesh, and to be able to collect it into a 500 mm spectrometer (mod. Acton SP2500i, Princeton Instruments, US).

OAS acquisitions were performed using a grating with a resolution of 150 mm^{-1} and setting a width of 10 µm for the inlet slit of the spectrometer. With the aim of achieving fast acquisition with a time resolution of 40 ms, a photomultiplier tube (PMT-Princeton Instruments PD439, US) connected to a fast oscilloscope (Tektronix MSO46) was used as a detector. The PMT amplification factor was fixed at 565, and it was kept constant for all measurements.

The concentration of Reactive Oxygen and Nitrogen Species (RONS) in the closed chamber was calculated spectrally resolving the collected beam and taking the Lambert-Beer Law into account:

$$\frac{I}{I_0} = e^{(-L\sigma n)} \quad (1)$$

where the concentration of the absorbers (n), which has to be quantitatively evaluated, is correlated with the light absorbed after an optical path of length (L) and expressed as the ratio between the initial light intensity (I_0) and the residual light intensity (I) after passing thorough the absorbers region. The absorption cross-section σ is a function of the light wavelength ($\sigma = \sigma(\lambda)$). In the experiments, the optical path was 14 mm long.

The wavelengths selected to perform the acquisitions of O_3 concentration is 254 nm, according to are reported in (Moiseev et al., 2014), to maximise the absorption of the molecules relevant to our study while minimising the contribution, and thus the disturbance, of other absorbing molecules. The contribute of background radiation was subtracted from the measured values of light intensity.

3. Results and discussion

Mean ozone concentration values are reported in Figure 1 for the 10 and 20 min treatments for both gas mixtures.

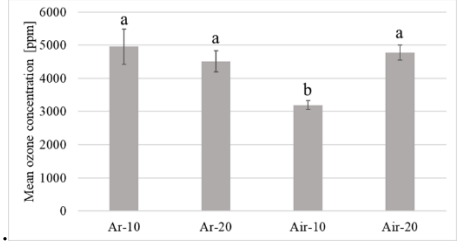

Figure 2. Ozone concentration values in 10 and 20 min of plasma treatment for both argon and air atmospheres.

Preliminary results on the use of CAP food matrices demonstrated the feasibility of this process for food decontamination. Nevertheless, results on the nutritional profile after CAP treatment have to be deeply investigated. In particular, the effect of CAP generated by a surface barrier discharge (SBD) was assessed on Aspergillus rugulovalvus (as sensible strain) and Aspergillus niger (as resistant strain) on dried tomatoes, and Escherichia coli and Listeria innocua on seabream filet. Results demonstrated that the germination of the spores was reduced and that CAP affected spore viability, promoting strong damage to the wall and cellular membrane; about 1 Log R can be reached using Ar20 treatment. Moreover, the physicochemical parameters and antioxidant activity of sundried tomatoes were not affected. [1] Furthermore, pistachio kernels were exposed to plasma, which did not cause significant changes in the whole composition of kernel lipids (fatty acids, alcoholic constituents of unsaponifiable matter) [3]

4. Conclusions

CAP is a promise novel tool in the field of food sanititation, but efforts have to be spent in order to identify and evaluate the effects induced by plasma treatment on physicochemical parameter, antioxidant activity and changes in composition.

5. Acknowledgements

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6. References

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