OPTIMIZATION OF PLASMA-ACTIVATED WATER PRODUCTION: THE ROLE OF ELECTRON PARAMAGNETIC RESONANCE IN FREE RADICAL DETECTION

F. Markić[1], V. Stulić[2], N. Maltar-Strmečki[1], T. Vukušić Pavičić[2]

[1]*Ruđer Bošković Institute, Bijenička cesta 54, 10 000 Zagreb, Croatia*

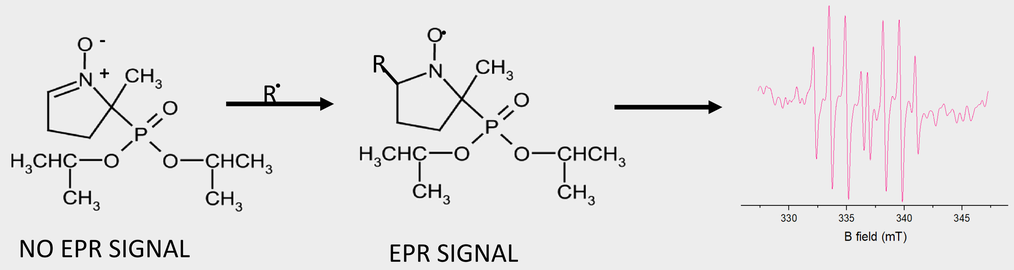
[2]*University of Zagreb, Faculty of Food Technology and Biotechnology, Pierrottijeva ul. 6, 10 000 Zagreb, Croatia*

e-mail: fmarkic@irb.hr

INTRODUCTION

Plasma-activated water (PAW) presents a promising alternative, as it has unique physicochemical properties due to differences in conductivity, pH, and chemical composition [1].

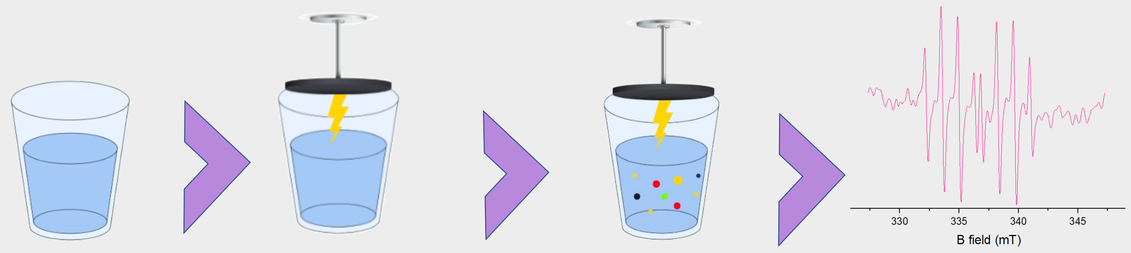
PAW's main active substances are reactive oxygen species (ROS) and reactive nitrogen species (RNS). Electron paramagnetic resonance (EPR) spectroscopy, utilizing spin traps, is commonly used to detect, identify, and quantify radicals in PAW [2].



NO EPR SIGNAL EPR SIGNAL

This study presents research results on the impact of plasma type and treatment parameters on radical generation in PAW.

MATERIALS AND METHODS



DISTILLED WATER → **PLASMA TREATMENT** → **ROS & RNS GENERATION** → **EPR DETECTION**

- Chemicals
  100 mL distilled water, 10 mM DIPPMPO spin trap, 15 mM Fe^{2+}, 30 mM H_2O_2
- Treatments ⟶ 5 -10 min; voltages 20 - 30 kV; frequency 120 Hz
- Instruments
  - plasma treatment
    high –voltage pulse generator HGV 60/1 PL (Impel d.o.o. Croatia)
  - EPR spin trapping measurements
    ESR5000 Bruker Magnettech (Bruker BioSpin, Germany)

RESULTS

The intensity of the EPR signal is directly proportional to the concentration of free radicals in PAW. **Figure 1** shows the impact of treatment time on the radical concentration in the PAW. Longer treatments (10 min) generate a higher concentration of free radicals than shorter treatments (5 min) at the same applied voltage (30 kV).

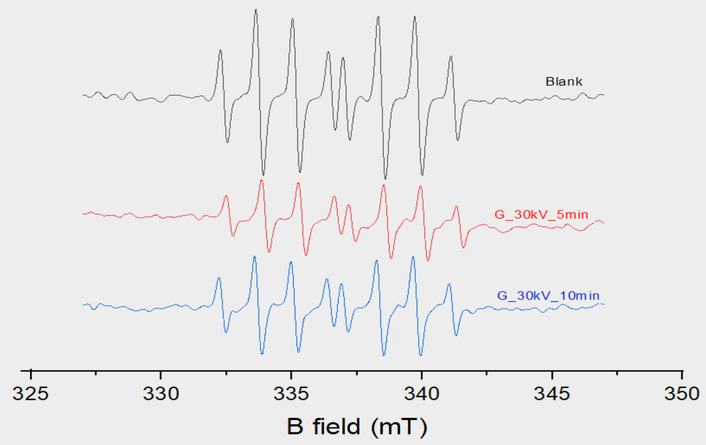
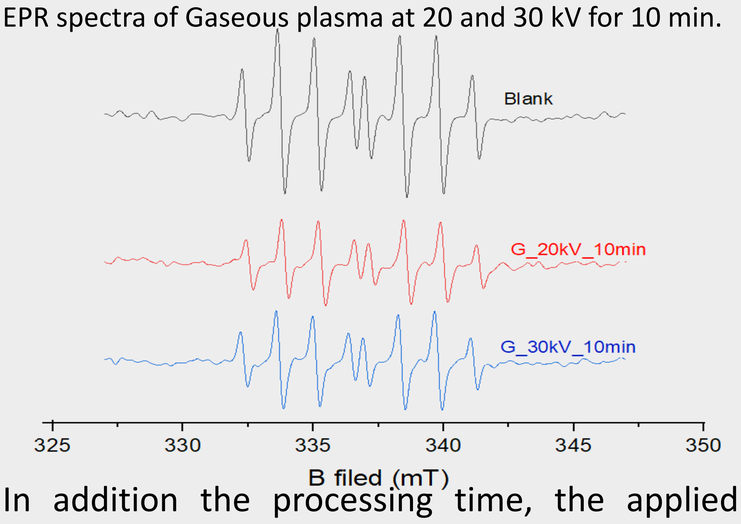


Figure 1. The impact of the treatment time on radical generation. EPR spectra of Gaseous plasma at 30 kV for 5 and 10 min.

Figure 2. The impact of applied voltage on radical generation EPR spectra of Gaseous plasma at 20 and 30 kV for 10 min.



In addition the processing time, the applied voltage plays a key role in the generation of free radicals in PAW. As well as treatment time, **Figure 2** shows that a higher applied voltage (30 kV) increases the EPR signal intensity, i.e. the concentration of free radicals in PAW.

Different types of plasma have different effects on the generation of free radicals in PAW. At the same applied voltage and duration, gaseous plasma generates a higher concentration of free radicals compared to liquid plasma, as shown in **Figure 3**.

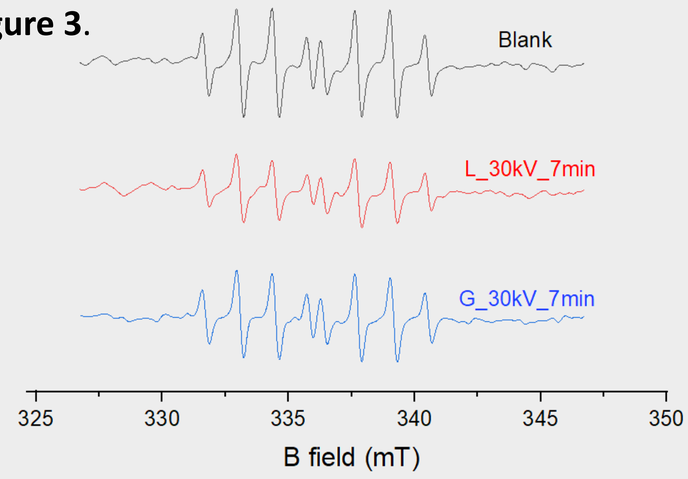
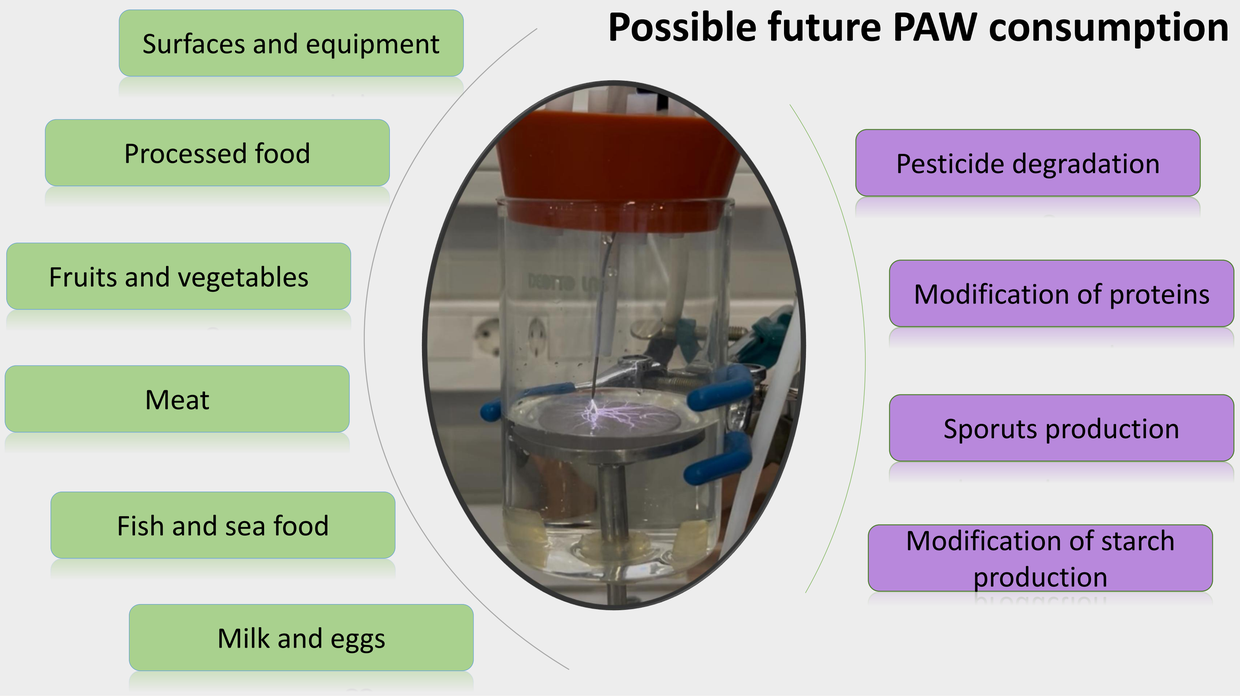


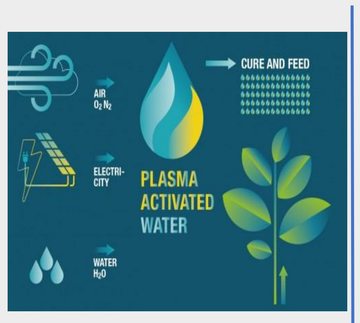
Figure 3. The impact of different types of plasma on radical generation. EPR spectra of Gaseous and Liquid plasma at 30 kV and 7 min.

Possible future PAW consumption



CONCLUSIONS

The EPR evaluation of PAW provides insight into the detection and quantification of free radicals produced in PAW. The free radicals concentration in PAW highly depends on the applied voltage and treatment time. A careful selection of parameters leads to PAW production with a satisfactory amount of free radicals, which, along with other PAW properties, will determine its future use.



Acknowledgments

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