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Plasma activated water generated by transient spark discharge for seed germination and plant growth

Kučerová K¹, Henselová M², Machala Z¹, Hensel K¹

¹*Faculty of Mathematics, Physics and Informatics, Comenius University, Bratislava, Slovakia*

²*Faculty of Natural Sciences, Comenius University, Bratislava, Slovakia*

E-mail katarina.kucerova@fmph.uniba.sk

Low-temperature plasma generated by electrical discharges in atmospheric pressure air is a source of various reactive species, free radicals and charged particles. If the plasma is generated in a contact with water, the reactive species formed in the gas-phase transfer into the water and generate plasma activated water (PAW). The PAW has a potential to be also used in agriculture applications. The reactive species in the PAW may act like signal molecules inducing the seed germination and also be a source of essential nutrients necessary for the plant growth [1,2].

We generated the PAW by DC driven pulsing transient spark discharge at atmospheric pressure above the circulating water solution [3]. Plasma induced chemical changes in various O₂/N₂ gas mixtures were analyzed and correlated with chemical changes in water solutions. Gas phase products were analyzed by FTIR absorption spectroscopy, while for the analysis of the reactive species in the liquid phase ($\cdot\text{OH}$, H₂O₂, NO₂⁻, NO₃⁻) we used the colorimetric and fluorescence UV-VIS methods. We monitored the reactive species' concentration in PAW in dependence on treatment time and also their post-treatment time decay. The effect of PAW on seed germination and plant growth on several seeds (wheat, radish, cabbage, spinach, lettuce, etc.) was studied. It was necessary to optimize the treatment time to achieve desired concentrations of reactive species in water, otherwise the inhibition could occur.

The characteristic concentrations of H₂O₂, NO₂⁻ and NO₃⁻ in 1 mL of PAW treated for 1 min in air were approximately 0.75 mM, 0.5 mM and 0.75 mM, respectively. The preliminary experiments with wheat seeds showed 10% increase in germination rate and small increase in dry weight of wheat seedlings. The optimal effect on the growth parameters was observed for the treatment time in the range 0.4 – 0.6 min/mL. Different results are expected for other plants/vegetables as they may have different requirements for living environment.

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