Plasma-generated reactive species in liquids by a gas shielded atmospheric pressure plasma jet effluent

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A shielded effluent has an important influence for the plasma-generated reactive species in physiological solutions. The composition of the shielding gas affects the reactive component composition of the plasma and thus the interaction of plasma and liquid. As an example for cell and mircobiologically important species, the final products of plasma generated NO, nitrate and nitrite were investigated.

By shielding the effluent of an atmospheric pressure plasma jet with different ratios of O_2 and N_2, control of reactive species in an enviromental independent manner is possible [1]. This controlling of the plasma/gas phase leads to different concentrations of plasma-generated reactive species in plasma-treated liquids, such as cell culture media, sodium chloride solution or bacterial suspensions.
To determine the differences between variations of shielding gas composition, concentrations of H^+ (pH value), H_2O_2 and the detection of absolute concentration of nitrate and nitrite in the plasma-treated liquids (figure 1) were measured. Nitrite and nitrate are final products of NO *in vivo* (eq. 1 to 3). NO is a strongly bioactive molecule relevant in cell signalling processes. The relevance of nitrite and nitrate in plasma treated liquids for biological experiments is known [2]. Because of the reaction of nitrate to nitrite or vice versa (eq. 4) the ratio of NO_2^- and NO_3^- is variable. For the total NO production in a system the sum of both is a good index.

$$NO + O_2^- \rightarrow ONO_2^- \xrightarrow{H^+} NO_3^- + H^+ \quad (1)$$

$$NO + O_2 \rightarrow N_2O_3^- \xrightarrow{2H_2O} NO_2^- + NO_3^- \quad (2)$$

$$NO + NO_2 \rightarrow N_2O_3 \xrightarrow{H_2O} 2NO_2^- \quad (3)$$

$$NO_3^- + 2\,H^+ + 2\,e^- \longleftrightarrow NO_2^- + H_2O \quad (4)$$

Further measurements for the detection of free radicals in physiological relevant solutions were performed and will be presented. The working distance between plasma jet nozzle and liquid (5 mL in a 60 mm petri dish) was 9 mm, the applied electric power of the plasma jet was approximately 3 W.
Additionally to the liquid analysis, cellbiological and microbiological tests were implemented. The cellbiological tests were done cooperatively with the Cellular Effects Group at the Centre for Innovation Competence *plasmatis*. The microbiological investigations were performed together with PlasmaVitro of the Campus PlasmaMed at the Leibniz Institut for Plasma Science and Technology (INP) Greifswald. The results clearly show the influence of different gas compositions in the gas curtain on plasma-treated liquids [3]. Biological relevance was investigated in a cell vitality test (figure 2) as well as in a decontamination experiment.

References

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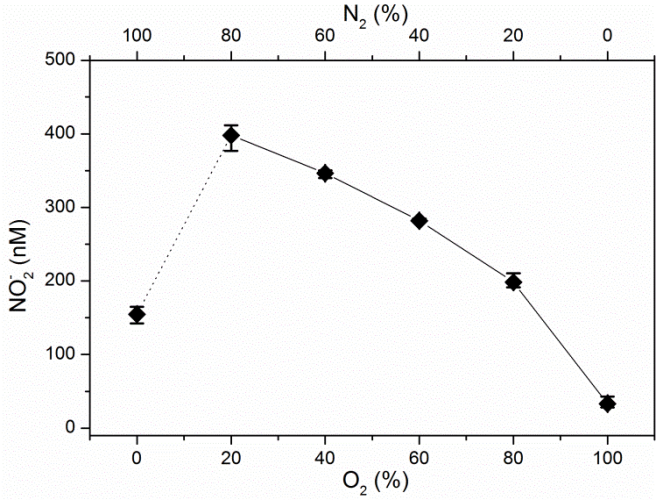

Fig. 1: Nitrite concentration in 5 mL NaCl solution after 10 min plasma-treatment with different shielding gas compositions.

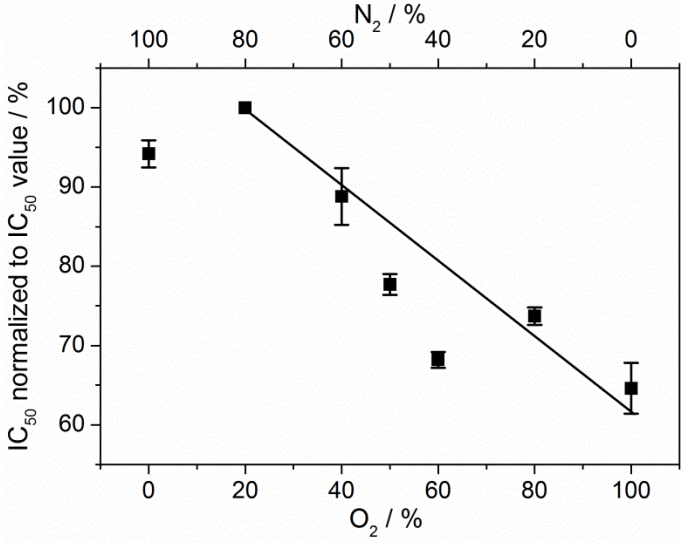

Fig. 2: Cell viability/ cell division test of HaCaT cells treatment over different shielding gas compositions.