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Testing the capabilities of a commercial economical power supply in plasma medicine

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Plasma medicine is an emerging research field with potential to impact across a range of healthcare and industrial sectors including wounds, cancers, dentistry, gene transfection, stem cell therapy, and in food and agriculture [1,2,3]. The biological and medical effects of plasma are generally attributed to reactive oxygen species (ROS) and reactive nitrogen species (RNS), commonly known as RONS, generated by plasma in ambient air. Plasma jets are highly preferred for this as they provide a means to remotely deliver these reactive species to biological surfaces. Depending on the type and concentrations of RONS, plasma jets can induce stimulatory effects (e.g., for promoting wound healing) or inhibitory effects (e.g., for killing cancer cells or bacteria).

A variety of power supplies are used to operate plasma jets with some costing tens of thousands of US dollars (e.g., high voltage DC power supplies that enable precise control over the electrical parameters). However, a lot of plasma medicine researchers have utilised a more economical power supply PVM500 (Information Unlimited, USA) which fits within their budgetary requirements as it costs well below 1000 US dollars. The PVM500 provides AC high voltage with capability of being operated over a wide voltage and frequency range (depending on how it is optioned). Despite the widespread use of the PVM500 in plasma medicine, no prior studies have examined the implementation of its in-built duty cycle control feature. Therefore, this paper explores this feature through a comprehensive investigation of how adjustment of the duty cycle influences the intrinsic properties of the plasma jet and subsequently how this can be used to optimise the plasma jet for plasma medicine.

Our results obtained from electrical and optical methods highlight the correlation between duty cycle, power dissipation, and gas temperature in the plasma jet. As the time-on period increases, more energy is transferred into the gas that affects the production rate of H and O atoms, which is an important precursor for the generation of hydrogen peroxide (H_2O_2). H_2O_2 is a major ROS produced by plasma jets in medicine that intervenes in cellular signaling processes important for disease treatment.

Figure 1 demonstrates the influence of varying the duty cycle on the efficiency of the plasma jet to produce H_2O_2. This was assessed by measuring the concentrations of H_2O_2 in 300 μL of water following 1, 2 and 4 minutes treatment in a 96-well plate as per previously published protocols [4]. Furthermore, to assess the biological impact, skin-like HaCaT keratinocyte cells were plasma treated using different duty cycles. The results indicate that the higher duty cycles could be more detrimental to the cells under study.

Overall, this study the duty cycle of PVM500 power supply can effectively modulate the thermal and chemical characteristics of the plasma jet in a similar level of control as more expensive DC power systems.

References

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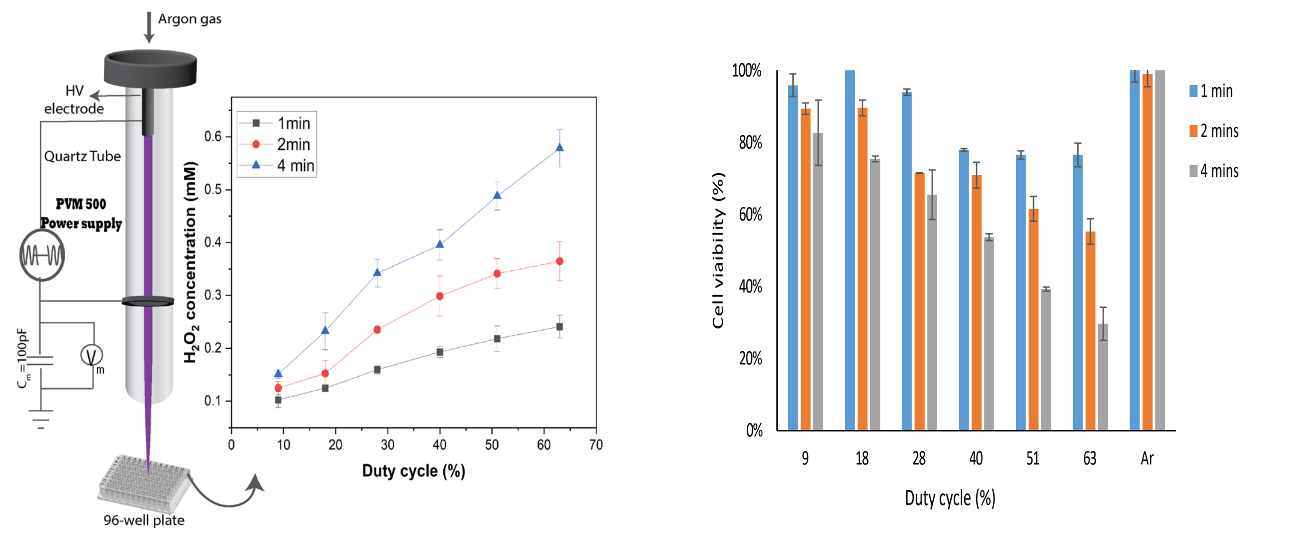

Figure 1. Plasma jet used in this study with the concentration of H_2O_2 (mM) as a function of duty cycle (%) (left graph) and the effect of duty cycle on HaCaT cell viability (right graph).