Characterisation of an Atmospheric-Pressure Dielectric Barrier Discharge in Air and a Protocol for Comparing the Biocidal Properties of Plasma Devices

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Low temperature atmospheric pressure dielectric barrier discharge plasmas can be used in a wide range of applications including ozone production, surface modification, sterilisation and medical treatments. They utilise the convenience of atmospheric pressure operation and their inherently low operation temperature meaning that sensitive targets can be exposed to the plasma without undergoing thermal damage.

Plasma is not widely used for sterilisation or cleaning purposes as more work is needed to develop an optimised power supply and plasma device that is capable of repeatable bacterial inactivation; we also do not fully understand which components of plasma kill bacteria and how this is carried out.

Here we report both the characterisation of a plasma device by Ultraviolet (UV) & Infra-red (IR) absorption spectroscopy and also electrical characterisation by means of power, voltage and frequency measurements. UV absorption at 256 nm is used to measure the temporal evolution of ozone concentration and FTIR spectroscopy is used to measure the concentration of HNO_3, N_2O, N_2O_5 and NO_2 plasmas a function of the electrical input parameters.

The plasma was driven by an in-house built half-bridge resonant power supply. The frequency during the experiments was varied between 11 and 16 kHz which affected the operating voltage of the plasma as well as the power. The duty cycle was also varied in order to control the temperature of the plasma chamber between 5 and 25% on time. Air flow in the chamber was varied during the ozone concentration measurements between 0 and 2 SLM.

The idea of quantitive antibacterial characterisation is bridged with the proposal of a biological sample preparation protocol for producing bacterial samples to test the antibacterial efficacy of a plasma device. While reviewing literature around bacterial inactivation, we noticed that different institutions report drastically different reductions in bacterial reduction after plasma treatments even with similar operating regimes.

A reference protocol for bacterial preparation is proposed in the form of gram positive *Bacillus subtilis* spores (ATCC 6633) deposited as a monolayer on a polycarbonate membrane. The advantages of using this particular bacterium are that it is non-pathogenic, and once produced, spores stocks can be kept for many years with only a negligible reduction in viability. Using spores from a stock obviates the need to produce micro-organisms at a particular phase of growth for each experimental trial, which reduces variability between experiments and speeds up the experimental procedures. Results from testing of the above bacterial sample preparation protocol by both plasma and UV exposure are presented along with analysis of the error in results when compared to standard sample preparation protocols.