Characterisation of an Atmospheric-Pressure Air DBD Discharge

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Combining the advantages of non-equilibrium plasmas with the ease of atmospheric-pressure operation, dielectric barrier discharges (DBD) are widely used in many fields and applications, including ozone production, sterilization, tumour treatments and surface modification.

Here we report on the characterisation of an air surface DBD discharge (Figure 1) that is intended for cleaning and pre-treatment of abiotic surfaces. It is known that pre-treatments with oxidizing plasmas improve the wettability and bondability of the substrates, and this study is motivated by the fact that air discharges can produce a number of oxidizing species. Despite the simplicity of the device, the chemistry of atmospheric pressure air discharges is fairly complex. Of particular interest are long-lived reactive species such as ozone (O_3), which can diffuse from the active plasma region to the substrate under treatment. Ultraviolet (UV) and Infra-red (IR) absorption spectroscopy have been used to identify these species and to assess their yield as a function of various discharge conditions (input electrical parameters and flow rates).

The plasma was driven by an in-house built half-bridge resonant power supply. The electrical parameters adjusted in the study were the operation frequency (11~16kHz), which also determined the applied voltage, and the duty cycle at which this one was modulated. In general, as the average power delivered to the plasma increases, reactive species are produced at a faster rate and the final concentration of NO_2, N_2O, N_2O_5 and HNO_3 are found to increase.

Ozone's net production, however, does not follow the same trend as NO_x. After an initial increase in O_3 concentration with increasing input power, an optimum power level for O_3 production is found. Any further power increase results in a lower ozone yield, including total ozone destruction at high power levels. Ozone yield is also influenced by the air flow rate in the system, with final O_3 concentrations decreasing at low flow rates. Ozone thermal decomposition and a discharge poisoning mechanism where the accumulation of nitrogen oxides leads to the quenching of ozone are believed to be responsible for the trends observed.

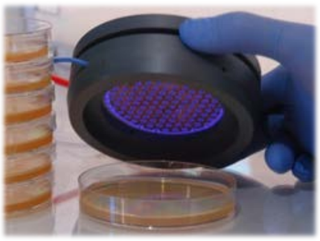

Fig. 1. Atm-pressure air DBD treating agar on a Petri dish.

These results indicate that for surface treatments in which ozone is a primary agent, discharge conditions in air DBDs need to be carefully controlled.