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Optical diagnostic of atmospheric pressure surface dielectric barrier discharge plasma

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The application domain of nonthermal atmospheric pressure plasma has expanded to various novel areas in recent years. However, due to higher collision frequency, developing a homogenous plasma for large-scale treatment remains a nontrivial task. Further generating an adequate amount of reactive chemical species (RCS) while maintaining the nonthermal nature is also very challenging. In this regard, recently, we have investigated the feasibility of Surface dielectric barrier discharge (SDBD) plasma for wastewater treatment applications. SDBDs have emerged as a potential choice for nonthermal plasma systems for large-scale operations. The major attraction is that these plasmas are scalable, and the plasma operation does not get affected by treated sample properties.

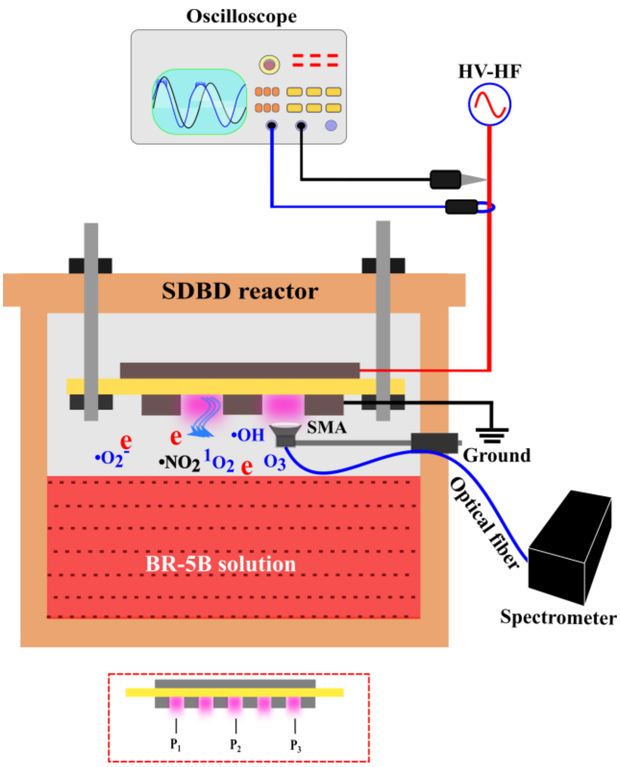

Fig 1: Experimental schematic of SDBD reactor along with the optical and electrical measurement setup.

Fig 1. shows the schematic of the SDBD reactor. Optical emission spectroscopy (OES) measurements were recorded and coupled with the collision radiative (CR) model to extract information of crucial plasma parameters such as electron temperature and density. The results establish that the SDBD can produce energetic electrons with an average energy of 1.6 eV, assuming the Maxwellian electron energy distribution. Also, the electron temperature was uniform across the entire discharge area.

Further, the efficiency of the reactor was investigated by studying the degradation and mineralization of azo dye (Brilliant Red 5B) in water at ambient conditions. The •OH and H_2O_2 reactive species quantification were carried out under various operating conditions. The experiments were performed as a function of initial dye concentration, pH, and background salts such as NaCl, Na_2SO_4, and Na_2CO_3 to study their effect on dye degradation.

Enhanced generation of •OH and H_2O_2 was observed, leading to faster degradation and mineralization of Brilliant Red 5B. For example, the degradation and complete mineralization of 50 mg/L of dye concentration was achieved at 20 min and 72 min, respectively. Compared to other plasma reactors, the SDBD showed a high energy yield of 247 mg/kWh at an operating power of 60 W and an initial dye concentration of 50 mg/L. In short, the study demonstrated that the SDBD reactor is an energy-efficient and promising technology for degrading and mineralizing complex organic molecules like BR-5B in water. The SDBD can generate uniform discharge over a large treatment area with flexible operation and low maintenance.

A detailed description of the SDBD setup, OES measurements, CR model, and reactive species variation under various operating conditions will be presented at the conference.

References:

S. M. Allabakshi, PSNSR Srikar, R. K. Gangwar, and S. M. Maliyekkal, "Feasibility of surface dielectric barrier discharge in wastewater treatment: Spectroscopic modeling, diagnostic, and dye mineralization," Separation and Purification Technology, (2022), **296** (2022) 121344.