Spectroscopy study of a barrier single micro-discharge with thin water layer as second electrode.

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With human's increasing impact on environment, different types of organic pollutants are detected more frequently in surface water, ground water and drinking water all over the world [1]. Amongst different proposed advanced oxidation processes (AOP), the use of low temperature plasma for water treatment may prove to be a sustainable and efficient approach. Amongst various plasma reactor configurations that have been investigated, AC powered direct barrier discharge over moving water film has been found to be both energy efficient and sustainable [2,3]. Up to now, studies on plasma initiated decomposition of organic compounds have focused mostly on H_2O_2 and O_3 generation, chemical processes, energy efficiency and by-product formation [4,5]. Nevertheless, little attention has been given to characterization of the discharge itself in water treatment reactors.

In our prior research, a plasma reactor was used based on dielectric barrier discharge (DBD) in cylindrical geometry for decomposition of organic micropollutants. In the reactor, plasma is generated between a dielectric barrier made of quartz glass and a falling water film on active carbon textile, by applying AC 50 kHz high voltage. The scheme of the reactor is presented in figure 1.

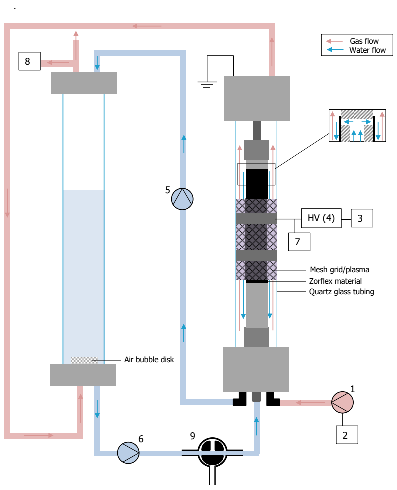

Figure 1: Schematic overview of the reactor. 1 Mass flow controller; 2 PR 4000 controller; 3 TGP 110 pulse generator; 4 High voltage power generator; 5 custom peristaltic pump; 6 Roth cyclo II peristaltic pump; 7 Tektronix TDS 210 oscilloscope; 8 M450 ozone monitor and 9 3 way ball valve (T-shaped)

The DBD plasma consists of numerous microdischarges, which move randomly in between the electrodes. This complicates accurate investigation of plasma characteristics, which requires more stable plasma. To this end, we proposed a DBD system where a single, stable microdischarge filament is generated in between a water film on a spherical metal grid and a dielectric barrier. In order to produce a microdischarge representative for the water treatment plasma reactor, AC high voltage with the same frequency of 50 kHz and amplitude of 10 kV is used.

The single microdischarge is studied by means of ICCD imaging with 1 µs resolution. It is found that every half a period, 2 discharge phases are observed separated in time, one of which makes contact with the water film and one of which is located solely at the glass barrier. It was found that the emission spectrum of the discharge is dominated by vibrational bands of the N_2 second positive band system $C\ ^3\Pi_u(v') \rightarrow B\ ^3\Pi_g(v'')$, indicating the presence of excited N_2 molecules. These N_2 states formed in air plasma are involved in formation of O and O_3 [6]. Despite the presence of atomic oxygen in the plasma, emission lines of excited oxygen atoms are very weak, such as the O^I triplet at 777.5 nm. The emission of the OH(A-X) (0,0) Q band head around 309 nm and the OH(A-X) (1,1) band around 315 nm which partially overlapped with the N_2^* bands indicates the presence of excited OH radicals. Time resolved dynamics of the discharge has been studied with a PMT tube with detection of following lines and bands: OH (298 nm), OH (309 nm), N2 band, O (777.5 nm), and H_α. Rotational and vibrational temperature of OH and N_2 bands are estimated with Boltzmann plot method. Electron density is deduced from the current density, taking into account calculation of electron mobility in Bolsig+ and reduced electrical field E/N in Comsol.

In summary, single micro-discharge with liquid electrode is studied by variety of spectral methods and main physical properties of the discharge are determined.

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