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Study of the improvement of Ozone production: A simulation

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Ozone is an unstable, colourless gas that has a pungent odour which occurs naturally in small amounts in the stratosphere. Ozone is one of the strongest oxidants. Major applications of ozone are disinfection, deodorization, decolourization, bleaching processes, semiconductor industry, treatment of industrial wastes, treatment of flue gases, chemical synthesis, potable and wastewater treatments etc. In many industrial applications, ozone is being used as an alternative oxidant for chlorination processes. It has a minimal negative impact on the environment and the extra benefit of requiring less energy for its production than other alternatives. This work was focused on a numerical simulation using MATLAB software and this study was aimed at understanding the discharge phenomenon in the ozoniser in detail, which could not be observed by experiments. It considered the rate coefficients of different plasma chemical reactions as a function of time using a single pulse and multiple pulses. The simulation study was carried out using differential equations of the plasma chemical reactions with the peak pulsed voltage (42.5 kV), pulse repetition rate (100 pulses per second, pps), input energy per pulse (~0.22 J), pulse width (FWHM 100 ns), flow rate (3.0 l/min), the gaseous gap spacing (36 mm), the reactor length (1 m) and 1 cm pitch length of the spiral wire forming the central electrode at a pressure of 1.01×10^5 Pa and a temperature of 293 K. A central copper wire (1 mm in diameter) made to a cylindrical configuration (22 mm in diameter) in a concentric coaxial electrode system without a dielectric barrier was considered. The concentration of ozone was found for a single pulse as well as for multiple pulses, and the production yield of ozone was found at different concentrations. The dependence of the densities of atomic oxygen, excited and ground state of molecular oxygen has been investigated. The concentration of ozone reached a saturated value of 137.2 ppm after about 18 μs when a single pulse was applied. When a large number of pulses (10^5 pulses) were used, ~33% of ozone could be produced from oxygen. The production yield of ozone was found to be strongly dependent on the concentration of ozone and it showed an optimal behaviour for each and every repetitive pulse. The dependence of the concentration and production yield of ozone in oxygen on the parameters studied generally agreed with the published literature, thus confirming the validity of the simulation model. This study covered a wide range of ozoniser conditions, including low and high concentrations and low and high yields of ozone that can be applied to various industrial applications.

Keywords: Concentration, Plasma chemical reactions, Production yield, Rate coefficient