# Decontamination of biological suspensions by pulsed corona discharges: Role of UV radiation, frequency and conductivity

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**Resumé**

Decontamination of bacterial suspensions by a pulsed corona discharges generated in a liquid phase was investigated. The inactivation effect of the pulsed corona discharge was studied in dependence on the solution conductivity (200 and 500 μS/cm), on the type of microorganism and the pulse repetition frequency. The role of UV radiation emitted by the electrical discharge in the overall bacterial efficiency was evaluated in dependence on the solution conductivity using a UV light transparent spectrometric cell. The reactor with a point to plate geometry of electrodes was used for generation of the discharge in liquid. Bacterial suspension of *Escherichia coli* and *Enterococcus faecalis* were used. Exposure of living forms of *E. coli* and .*E. faecalis* were inactivated by the pulsed corona discharges with respect of increasing conductivity. It has been shown that the contribution of UV light during the pulsed corona discharges is very important.

## Introduction

Previous research has demonstrated that the high voltage pulse electrical discharges generated directly in the liquid phase initiate a variety of chemical and physical processes. These processes include a high electric field, intense ultraviolet radiation, overpressure shock waves and formation of various highly reactive chemical species such as radicals, molecular radicals and ions. It was shown that these processes are capable to efficiently destroy a number of organic compounds and cause serious damages to microorganisms present in the liquid phase [1, 2].

Concerning the bactericidal effects of UV radiation, UV light (200–300 nm) with doses of several $mWs.cm^{-2}$ is known to cause lethal damage to cells. UV radiation affects the cells of bacteria by inducing the formation of thymine dimmers in the DNA. It suppresses replication of DNA [3, 4].

Electrical discharges in liquid phase can emit significant intensity of UV light [5]. Previous research obtained using the emission spectroscopy showed a radiation from the pulsed corona discharge in liquid phase in a wide range of wavelengths (200–1000 nm), which is dominated by the spectral lines of hydrogen (peaks at 434, 486, 656 nm) and oxygen atom (777 nm) and by emission from OH• radical (309 nm) [6, 7]. Consequently, Lukes et al. have determined that pulse radiant power (190–280 nm) of the corona discharge in liquid phase could reach levels of the order of tens to hundreds of watts during the pulse, which corresponds to the UV radiation intensity of the order 0.1–10 $mW.cm^{-2}$ in dependence on solution conductivity [5].

In this work the role of UV radiation in the bacterial inactivation caused by the pulsed corona discharge in the liquid phase is investigated in more detail. The inactivation effect of the pulsed corona discharge is studied in dependence on the solution conductivity (200 and 500 $\mu S.cm^{-1}$) and on the type of microorganism, *E. coli* (gram-positive bacterium) and *E. faecalis* (gram-negative bacterium). In addition, the effect of pulse repetition frequency of applied power to the discharge on the inactivation of bacteria was determined.

## Materials and methods

A needle to plate geometry of electrodes was used to generate discharges in liquid. Electrodes were totally immersed in a cylindrical reactor. High voltage was connected with needle electrode and plate electrode was grounded. The needle to plate distance was 52 mm. All experiments were conducted with fixed applied voltage of 27 kV, pulse repetition frequency of 35 Hz and charging capacitance of 7 nF. A pulsed high voltage applied to the needle was provided by a pulse power supply. Bacterial suspensions of *Escherichia coli* CCM 3954 and *Enterococcus faecalis* CCM 4224 were prepared by incubation lyophilized bacteria in gelatine disc obtained from Czech collection of microorganisms. Suspensions were adjusted by NaCl to 200 or 500 $\mu S.cm^{-1}$ before each experiment. Number of bacteria

was assayed by counting colony forming units in 1 ml. *E. coli* was cultivated on agar plates at temperature of 43°C for one day. *E. faecalis* was cultivates on agar plates at temperature of 37 °C for two days. The initial amount of bacteria was about $10^5$ CFU $ml^{-1}$.

**Results**

The spectrometric cell was filled with bacterial suspension, placed into the gap between the needle electrode and grounded electrode and irradiated by the light emitted from the discharge. Preliminary experiments performed with the Pyrex spectrometric cell, (i.e., which do not transmit UV light) revealed no inactivation of bacteria [5]. Thus, any other processes produced by electrical discharges than UV radiation did not influenced inactivation of bacterial suspension in the Quartz spectrometric cell except of UV light. Thereby this allowed us to investigate just the role of UV light in the bacterial inactivation by the discharge.

Table 1 shows particular contributions of UV to overall inactivation of both types of bacteria. The contribution of UV light was of about 40 %.

Another result presented in this work was that with higher solution conductivity and higher pulse repetition frequency is faster decontamination of the bacterial solution. *E. coli* needs for 5-log reduction more time than *E. faecalis*.

Table 1: Contribution of UV radiation in bacterial inactivation by the pulsed corona discharge.

| | *Enterococcus faecalis* | *Escherichia coli* |
|---|---|---|
| Cotribution of UV, 500 μS.cm$^{-1}$ [%] | 39 | 51 |
| Contribution of UV, 200 μS.cm$^{-1}$ [%] | 42 | 40 |

**Conclusion**

Results on the effects of the pulsed electrical discharge on inactivation of bacterial microorganisms in liquid phase were presented. It was shown that UV radiation emitted from the discharge contributes to the overall inactivation bacteria and its role increases with rising solution conductivity. About 40% contribution of UV radiation to the overall inactivation of *E. coli* or *E. faecalis* was estimated. With higher solution conductivity and higher pulse repetition frequency faster inactivation of microorganisms was obtained. Finally, better inactivation efficiency was determined for *E. faecalis* than for *E. coli*.

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