Abstract

This study focuses on the sterilization of bacteria at ambient temperatures using radio frequency (RF) plasma. The bacteria chosen for the sterilization study were *Staphylococcus aureus* (gram-positive), *Escherichia Coli* (gram-negative) and *Bacillus subtilis* (spore-forming). The preliminary objective was to determine the behavior and sensitivity between gram-positive and gram-negative bacteria towards different plasma exposures. The major challenge of this study was to sterilize spore-forming bacteria, which are said to be the most resistant of all microorganisms. To understand the effect of plasma parameters during sterilization, a parametric study was performed at different operating conditions. To realize the potential of RF plasma, a comparison study made with pulsed DC plasma. It was observed that RF plasma resulted in fast and efficient bacterial reduction when compared to pulsed DC plasma. In the case of RF plasma generated by different gases or gas mixture, the highest bacterial reduction was obtained while using nitrogen-oxygen plasma. The bacterial damage caused by plasma was quantitatively determined by germicidal effect, which refers to the logarithmic reduction of bacteria. The highest germicidal effect was found to be 6.82, 7.36, and 5.70 for *S. aureus, E. Coli*, and *B. subtilis* respectively. These results were supported by variation in absorbance and protein leakage quantity measurements. The presence of the active plasma species responsible for sterilization was confirmed through optical emission spectroscopy. Scanning electron microscopy studies provided evidence to the bactericidal effect due to plasma like breakage of bacterial cell wall, leakage of cellular contents or removal of organic materials out of the cell through etching. The mechanism behind the annihilation of bacteria was also elucidated. Furthermore to understand the physics of plasma, a mathematical modeling was attempted. This modeling aims to determine the electron density and electron temperature in argon plasma. To determine the electron density, collisional-radiative model was used; whereas optical emission spectroscopy studies were utilized to determine the electron temperature. This study demonstrates the promise and potential of low-pressure plasma as an efficient sterilizing agent under ambient temperatures.

Keywords: radiofrequency discharge; plasma; sterilization; optical emission spectroscopy; escherichia coli; staphylococcus aureus; bacillus subtilis.