دومین کنگره پلاسما پزشکی ایران
The 2nd Congress on Plasma Medicine
DECEMBER 11-12,2025
۲۱ و ۲۰ آذر ماه ۱۴۰۴
دبیرخانه دائمی کنگره پلاسما پزشکی ایران
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Pulsed Argon Arc Plasma Light as a New Tool for Efficient and Rapid Bacterial Inactivation

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Citation:
Aminjarrahi M, Sohbatzadeh F, Mirzanejad S, Ebrahimnezhad Darzi R, Rezanejad M. Pulsed Argon Arc Plasma Light as a New Tool for Efficient and Rapid Bacterial Inactivation. *Iran Biomed J*. Supplementary (2-2026): 5.

ABSTRACT

Introduction: Healthcare-associated infections pose a significant global threat. The limitations of conventional chemical disinfectants and continuous-wave UVC light have prompted the search for rapid, effective, and chemical-free alternative technologies. This study introduces a novel pulsed argon arc plasma light (PAAL) system as an efficient, rapid, and chemical-free alternative to conventional continuous-wave UVC germicidal lamps (GUV) for surface disinfection.

Materials and Methods: A lab-made PAAL system, utilizing argon gas at pressures of 40, 60, and 80 mbar and operating at 1 Hz, was fabricated. Its efficacy in inactivating *Escherichia coli* (ATCC 25922) and *Staphylococcus aureus* (ATCC 25923) was quantitatively evaluated and compared to a standard 15W GUV lamp. Bacterial colonies on agar plates were treated at a distance of 4 cm. The inactivation percentage was determined through digital image analysis after incubation. Additionally, optical emission spectra and UVC irradiance were characterized.

Results and Discussion: The PAAL system produced a broad optical spectrum with intense UVC emission lines. Increasing the argon pressure to 80 mbar significantly enhanced UVC irradiance, reaching 3195 µW/cm² at 254 nm—four times that of the GUV lamp (800 µW/cm²). For *E. coli*, the PAAL system achieved a 99.9% inactivation rate in 30 seconds (30 pulses), consuming only 1,677 Joules. In contrast, the GUV lamp required 900 seconds and 13,500 Joules to achieve a 99.6% inactivation rate. Similarly, the more resistant *S. aureus*, the PAAL system achieved 98.4% inactivation in 30 seconds, outperforming the GUV lamp (97.9% in 900 seconds). Statistical analysis confirmed the significance of pulse count and gas pressure.

Conclusion: The novel PAAL system demonstrates a paradigm shift in no-touch disinfection, offering superior speed, energy efficiency, and compactness compared to conventional GUV lamps. It holds exceptional promise for rapid decontamination cycles in clinical settings to combat healthcare-associated infections.

Keywords: Argon Plasma Light, Bacterial Inactivation, *E. coli*, Pulsed Light Disinfection, *S. aureus*

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