

Efficacy of Antimicrobial 405 nm blue light for Inactivation of Airborne Bacteria

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INTRODUCTION

Airborne transmission of infection is a critical concern in the clinical environment with 10-33% of hospital-acquired infections spread via air¹.

Violet-blue light has wide antimicrobial properties at exposure levels that are non-harmful to human cells². Its efficacy has been widely demonstrated against surface-deposited and liquid-suspended bacteria, and is being developed for clinical applications including wound decontamination and environmental disinfection³⁻⁶. This study aims to establish the germicidal efficacy of 405nm violet-blue light against airborne bacteria and compare susceptibility when exposed in liquid and surfaces.

METHODS

Light Source: The light source was an ENFIS PhotonStar Innovate UNO 24 405 nm LED array (Fig 1). Average irradiance was set at 22 mWcm⁻². Dose (Jcm⁻²) was calculated as irradiance (W cm⁻²) × time (s).

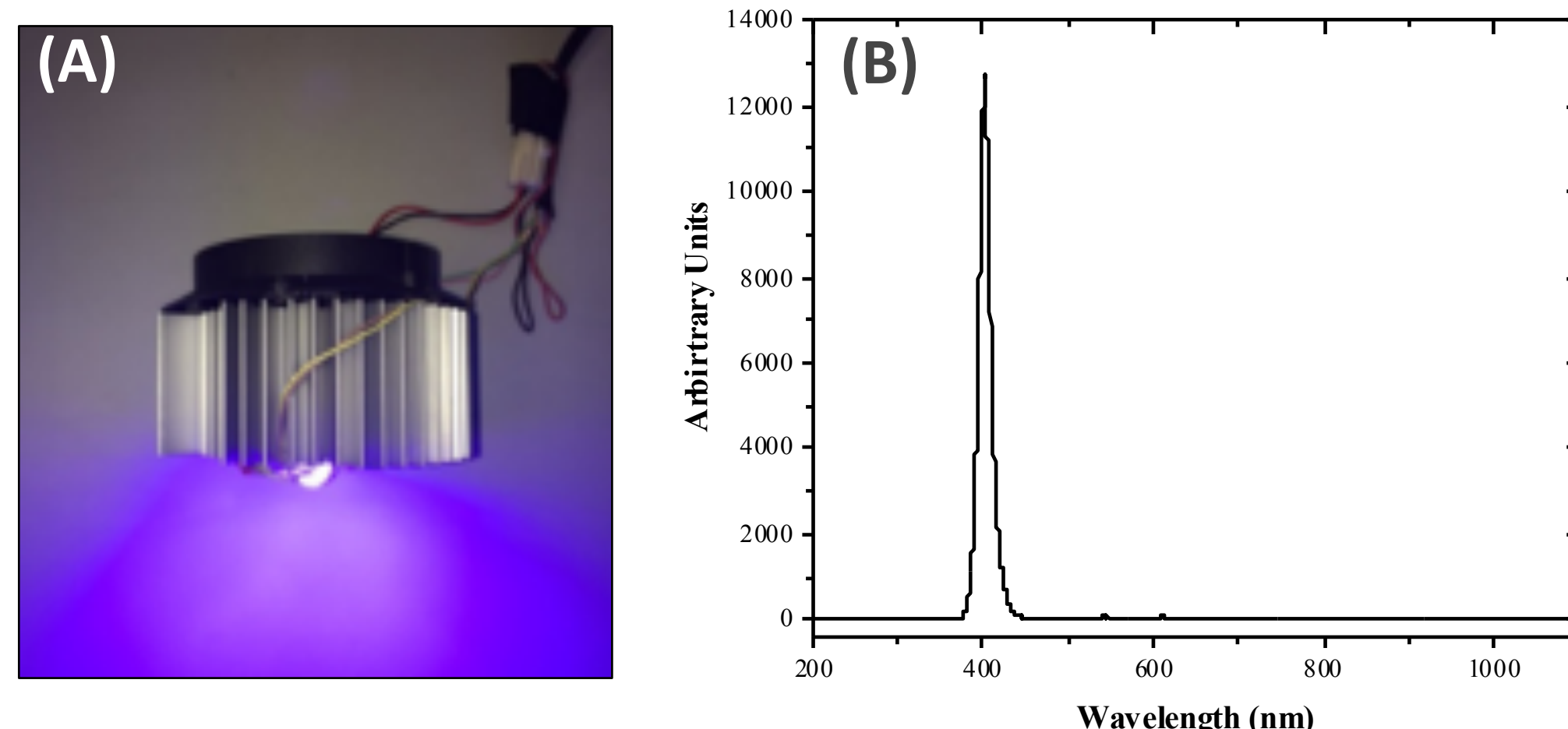


Fig. 1 (A) 405 nm LED array (B) and optical emission spectrum of LED array.

Air: Bacterial aerosols were generated using a 6-Jet Collision nebulizer (12.5L/min) & pumped into an aerosol test chamber (Fig 2).

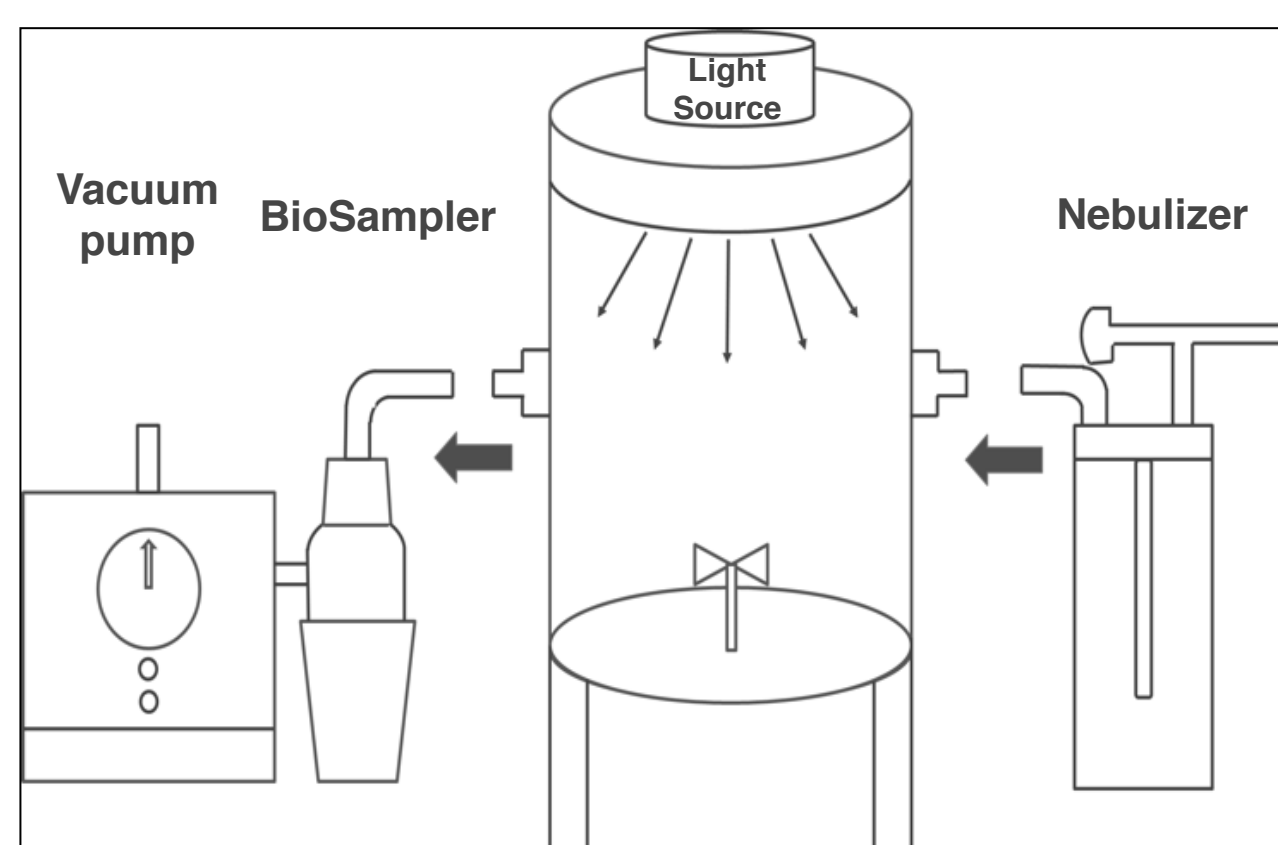


Fig. 2 Schematic system diagram. 4 additional LEDs were mounted to the chamber walls in addition to the top mounted light source.

Aerosols were exposed to increasing doses of 405nm light. Air samples were removed from the chamber using a BioSampler liquid impinger and the collection liquid was pour-plated, incubated at 37°C for 24h, and surviving bacteria enumerated.

Liquid: 3 mL volumes of bacteria suspended in PBS were exposed to increasing doses of 405 nm light. Samples were then plated, incubated & enumerated.

Surfaces: Bacteria were seeded onto agar plate surfaces and exposed to increasing doses of 405 nm light. Samples were then incubated and enumerated.

RESULTS

AIR

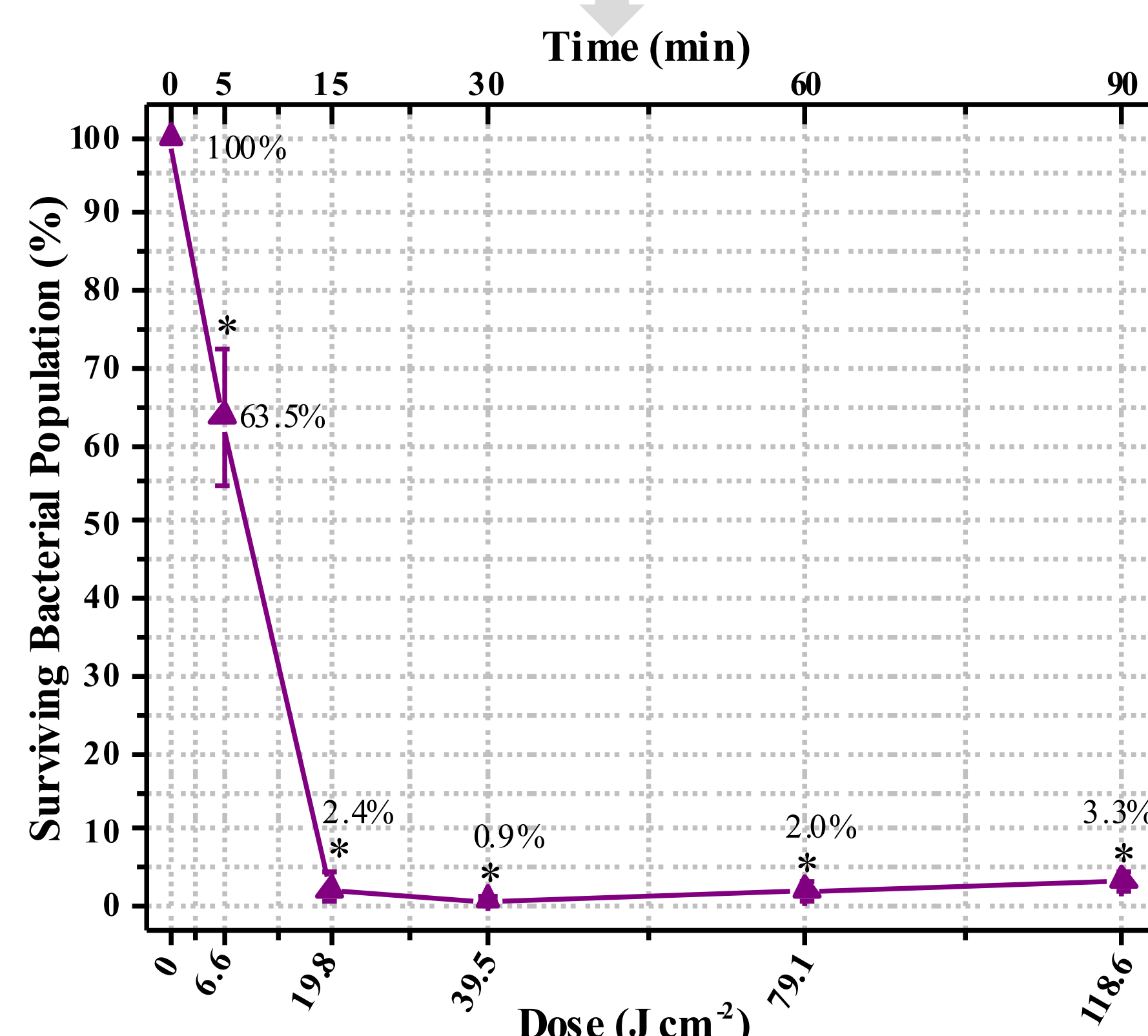


Fig. 3 Inactivation of aerosolized *S. epidermidis* by exposure to 405 nm light at an average irradiance of 22 mW cm⁻². * represents significant inactivation when compared to associated non-exposed control samples.

LIQUID

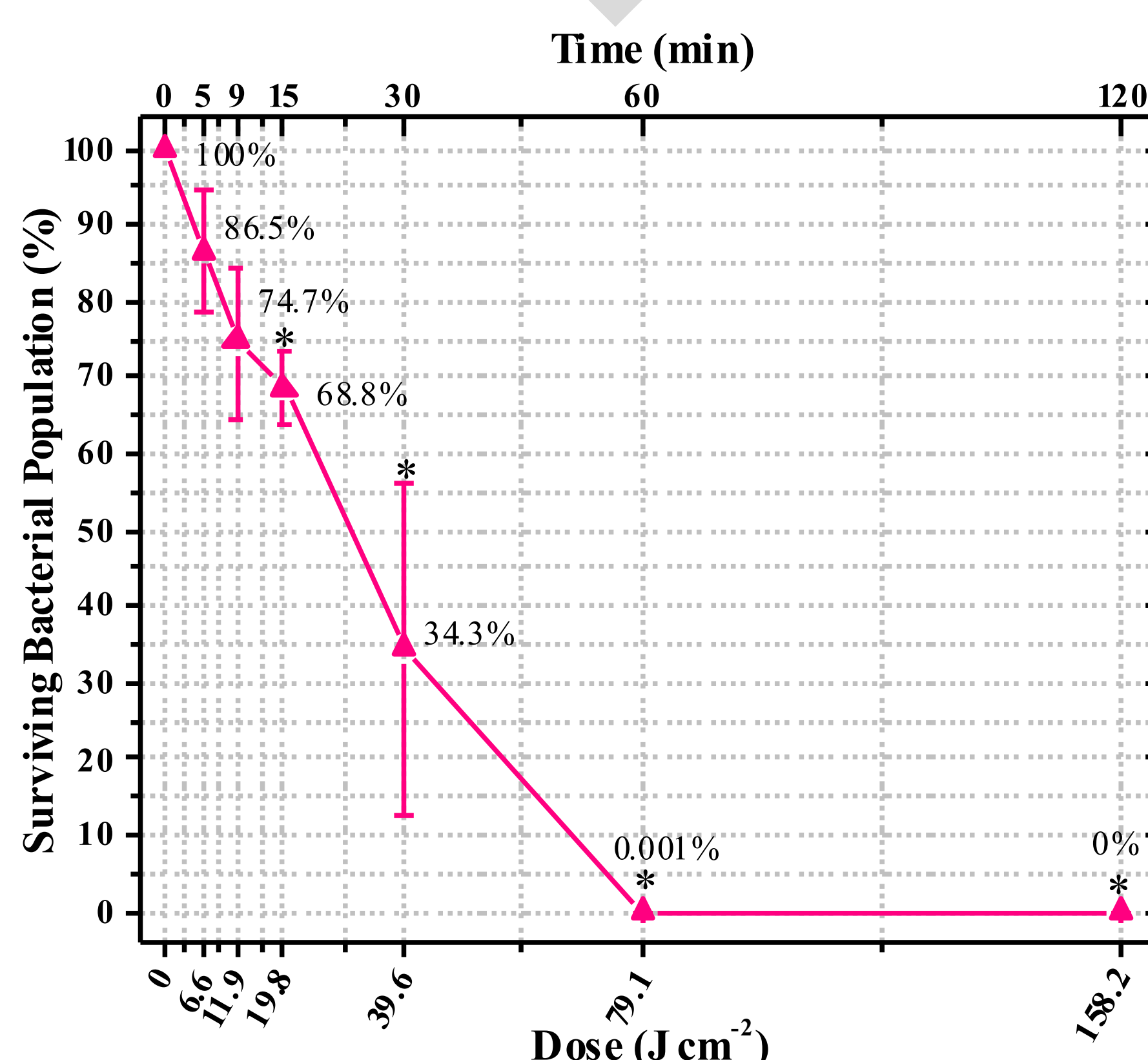


Fig. 4 Inactivation of liquid-suspended *S. epidermidis* by exposure to 405 nm light at an average irradiance of 22 mW cm⁻². * represents significant inactivation when compared to associated non-exposed control samples.

SURFACE

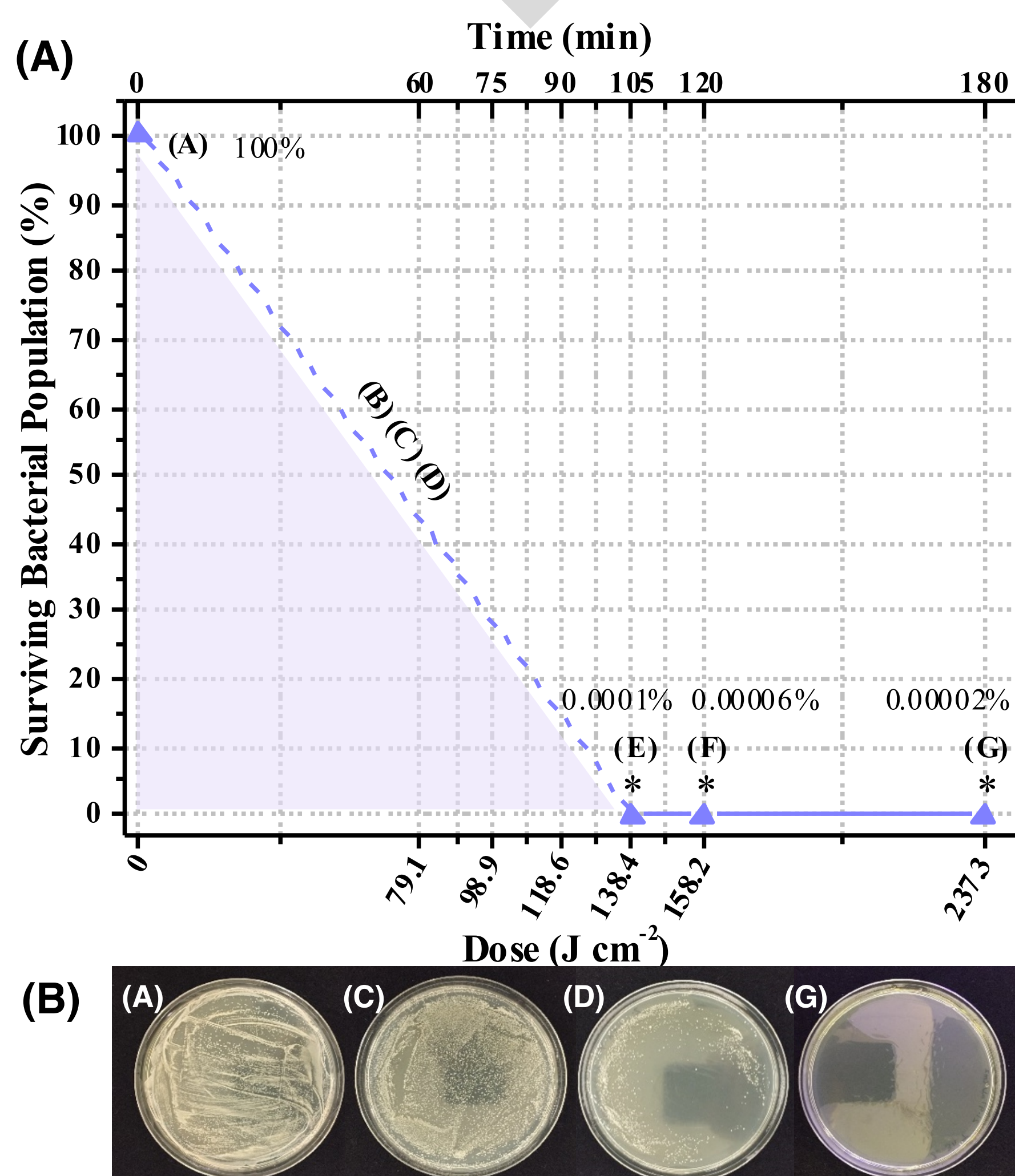


Fig. 5 Inactivation of surface-seeded *S. epidermidis* by exposure to 405 nm light at an average irradiance of 22 mW cm⁻². (A) Quantitative inactivation kinetics and (B) qualitative results showing agar plates seeded with bacteria and exposed to increasing doses of light treatment.

DISCUSSION

This study has successfully demonstrated the efficacy of 405nm light for inactivation of airborne bacteria, and highlighted the enhanced susceptibility of bacterial aerosols.

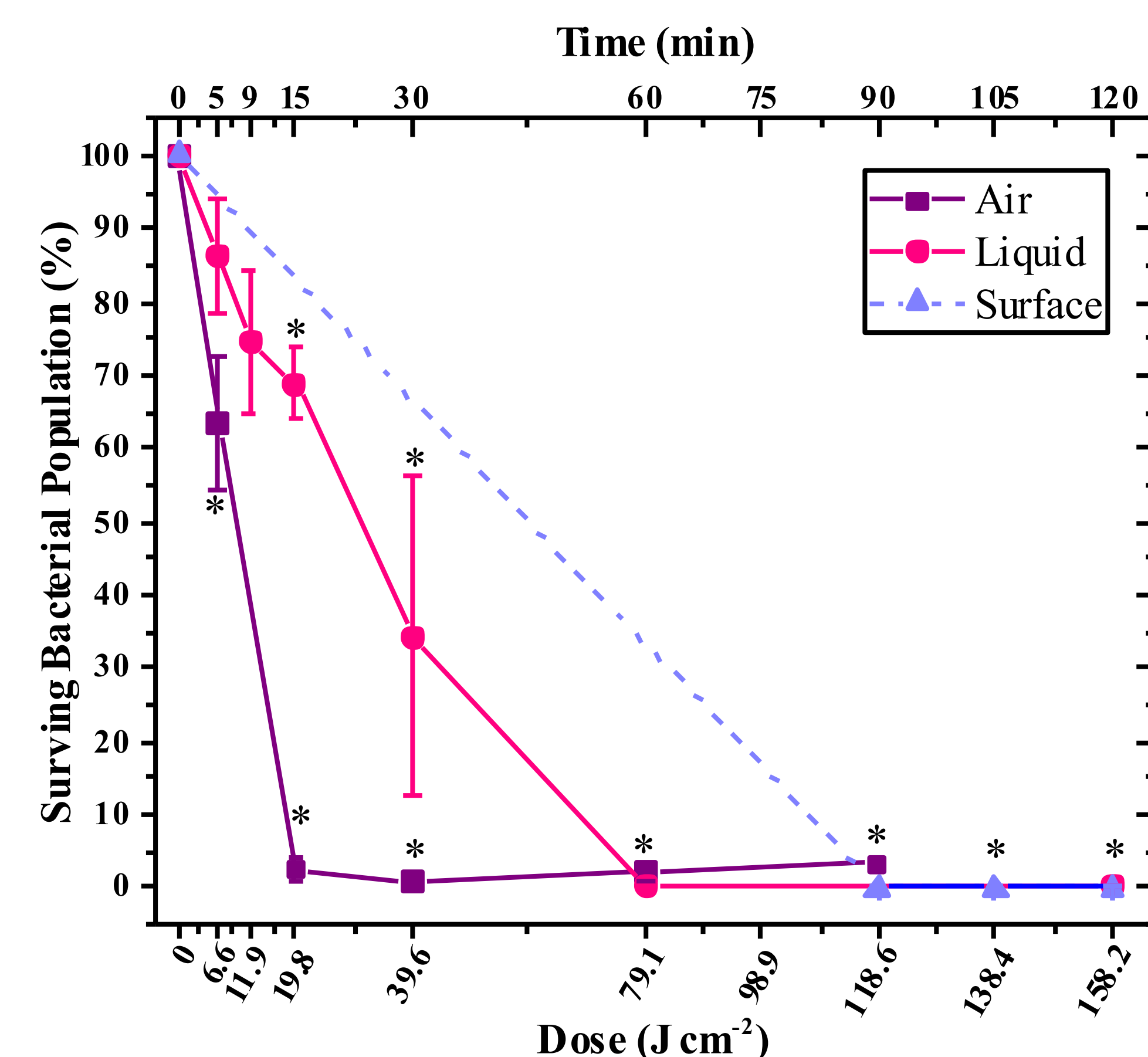


Fig. 6 Comparison of bacterial inactivation kinetics when exposed to ~22 mW cm⁻² 405 nm light in air, in liquid and seeded onto surfaces.

- At a dose of 19.8 J cm⁻², a 97.6% bacterial reduction was achieved in air, and only 31.2% reduction in liquid.
- Due to high population densities, quantitative data on surfaces was only available for doses >118.6 J cm⁻².
- It is likely that surface inactivation kinetics would follow a similar downward trend to that of liquids, or slower.

CONCLUSIONS

1. Airborne bacteria were readily inactivated by 405nm light.
2. Natural decay of the suspended aerosol was observed, however this was significantly less than with light treatment ($P < 0.001$).
3. Liquid suspended bacteria required a dose 3-4 times greater to achieve an initial significant degree of inactivation, and even greater for surfaces.

- These findings enhance the value of 405nm light technology for environmental decontamination, by demonstrating its potential to inactivate aerial contamination.
- Further work is required to fully characterize the dynamics of airborne bacteria and to establish the efficacy of 405nm light against natural aerial contamination.

REFERENCES

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