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Micropillar-Assisted Electric Field Enhancement for High-Efficiency Inactivation of Bacteria

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Abstract : Development of high-efficiency and environment friendly bacterial inactivation methods is of great importance for preventing waterborne diseases which are one of the leading causes of death in the world. Traditional bacterial inactivation methods (e.g., ultraviolet radiation and chlorination) have several limitations such as longer treatment time, formation of toxic byproducts, bacterial regrowth, etc. Recently, an electroporation-based inactivation method was introduced as a substitute. Here, an electroporation-based continuous flow microfluidic device equipped with an array of micropillars is developed, and the device achieved high bacterial inactivation performance (> 99.9%) within a short exposure time (< 1 s). More than 99.9% reduction of Escherichia coli bacteria was obtained for the flow rate of 1 mL/hr, and no regrowth of bacteria was observed. Images from scanning electron microscope confirmed the formation of electroporation-induced nano-pore within the cell membrane. Through numerical simulation, it has been shown that sufficiently large electric field strength (3 kV/cm), required for bacterial electroporation, were generated using PDMS micropillars for an applied voltage of 300 V. Further, in this method of inactivation, there is no involvement of chemicals and the formation of harmful by-products is also minimum.

Keywords : electroporation, high-efficiency, inactivation, microfluidics, micropillar
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