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Gigahertz acoustic streaming induced cell membrane poration towards intracellular delivery

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Efficient intracellular delivery of exogenous materials remains a critical issue in fundamental biological researches and clinical applications. Here, we developed a novel chemical-free method for intracellular delivery enhancement using a designed gigahertz ultrasonic electromechanical resonator. When excited by a sinusoidal electric signal, the propagation and attenuation of acoustic wave in liquid will generate high-speed acoustic streaming. The liquid above the device working area will be accelerated and strike the substrate surface, thus generates pressure on cells, induces deformation and membrane poration, and finally realizes delivery of exogenous materials. To verify the intracellular delivery ability, DOX was selected as an example, and an enhanced fluorescence of DOX in cells exposed to resonator stimulation can be seen. We also realized the delivery of fluorescent-labeled DNA strains and plasmids. Besides, different power applied to the resonator can induce different fluid velocity, thus generate different force intensity and control the deliver efficiency. Pores on membranes induced by acoustic streaming treatment were observed by SEM. Disrupted cell membranes and porous structures can be seen after treatment, and resealed after 10 min recovery, indicating a strong fluid force exerted on cells and the influence is temporary and reversible.

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