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Particle Deflection in a PDMS Microchannel Caused by a Plane Travelling Surface Acoustic Wave

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Abstract : The size selective separation of different species in a microfluidic system is an actual task in biological or medical research. Former works dealt with the utilisation of the acoustic radiation force (ARF) caused by a plane travelling Surface Acoustic Wave (tSAW). In literature the ARF is described by a dimensionless parameter κ, depending on the wavelength and the particle diameter. To our knowledge research was done for values $0.2 < \kappa < 5.8$ showing that the ARF is dominating the acoustic streaming force (ASF) for $\kappa > 1.2$. As a consequence the particle separation is limited by κ. In addition the dependence on the electrical power level was examined but only for $\kappa > 1$ pointing out an increased particle deflection for higher electrical power levels. Nevertheless a detailed study on the ASF and ARF especially for $\kappa < 1$ is still missing. In our setup we used a tSAW with a wavelength $\lambda = 90\,\mu m$ and 3 µm PS particles corresponding to $\kappa = 0.3$. Herewith the influence of the applied electrical power level on the particle deflection in a polydimethylsiloxan micro channel was investigated. Our results show an increased particle deflection for an increased electrical power level, which coincides with the reported results for $\kappa > 1$. Therefore particle separation is in contrast to literature also possible for lower κ values. Thereby the experimental setup can be generally simplified by a coordinated electrical power level for the specific particle size. Furthermore this raises the question of whether this particle deflection is caused only by the ARF as adopted so far or by the ASF or the sum of both forces. To investigate this fact a 0% - 24% saline solution was used and thus the mismatch between the compressibility of the PS particle and the working fluid could be changed. Therefore it is possible to change the relative strength between ARF and ASF and consequently the particle deflection. We observed a decreasing in the particle deflection for an increased NaCl content up to a 12% saline solution and subsequently an increasing of the particle deflection. Our observation could be explained by the acoustic contrast factor Φ, which depends on the compressibility mismatch. The compressibility of water is increased by the NaCl and the range of a 0% - 24% saline solution covers the PS particle compressibility. Hence the particle deflection reaches a minimum value for the accordance between compressibility of PS particle and saline solution. This minimum value can be estimated as the particle deflection only caused by the ASF. Knowing the particle deflection due to the ASF the particle deflection caused by the ARF can be calculated and thus finally the relation between both forces. Concluding, the particle deflection and therefore the size selective particle separation generated by a tSAW can be achieved for values $\kappa < 1$, simplifying actual setups by adjusting the electrical power level. Beyond we studied for the first time the relative strength between ARF and ASF to characterise the particle deflection in a microchannel.

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