Intra-droplet acoustic particle focusing: simulations and experimental observations

The aim of this paper is to study resonance conditions for acoustic particle focusing inside droplets in two-phase microfluidic systems. A bulk acoustic wave microfluidic chip was designed and fabricated for focusing microparticles inside aqueous droplets (plugs) surrounded by a continuous oil phase in a 380-μm-wide channel. The quality of the acoustic particle focusing was investigated by considering the influence of the acoustic properties of the continuous phase in relation to the dispersed phase. To simulate the system and study the acoustic radiation force on the particles inside droplets, a simplified 3D model was used. The resonance conditions and focusing quality were studied for two different cases: (1) the dispersed and continuous phases were acoustically mismatched (water droplets in fluorinated oil) and (2) the dispersed and continuous phases were acoustically matched (water droplets in olive oil). Experimentally, we observed poor acoustic particle focusing inside droplets surrounded by fluorinated oil while good focusing was observed in droplets surrounded by olive oil. The experimental results are supported qualitatively by our simulations. These show that the acoustic properties (density and compressibility) of the dispersed and continuous phases must be matched to generate a strong and homogeneous acoustic field inside the droplet that is suitable for high-quality intra-droplet acoustic particle focusing.

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