The Sound of Ink

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Abstract

Despite tattooing and tattoos having been around for thousands of years, scientific research on the topic is surprisingly limited. The role that ultrasound might play in the understanding of tattoos and tattoo inks is the topic of this thesis. This is of interest since ultrasound interacts with hydrophobic particles and therefore must interact with tattoo ink. This research is important because people want to detect, modify and remove tattoos. In this theoretical and experimental research, the size distribution, speed of sound, attenuation, and nucleation threshold of black tattoo ink was determined. Additionally, the effect that black tattoo ink has on tissues and brightness-mode ultrasound images was described. Finally potential sharpening effects of ultrasound on skin-cutting devices were demonstrated using a fixed blade as a representative device.

In the research presented it was found that black tattoo ink has a mode particle diameter of 0.29 μm and the largest particle diameter of 1.14 μm. The associated resonance frequency of the largest particles was 15 MHz, with the smaller particles even higher. The speed of sound and attenuation coefficient were determined to be 1639 $\mathrm{m\,s^{-1}}$ and 0.15±0.01 $\mathrm{dB\,cm^{-1}\,MHz^{-1}}$, respectively. The theoretical nucleation threshold was calculated to be 1.3× the resting radius and confirmed to be lower than the Blake cavitation threshold of 2× the resting radius. The change of the speed of sound and the attenuation coefficient was negligible due to *in situ* black tattoo ink. Critical refraction highlighting was introduced to describe the artefacts observed on brightness-mode ultrasound images. The sharpening effect of ultrasound on a fixed blade cutting device was demonstrated.

While the objectives were met and a greater understanding of tattoos and tattoo inks was demonstrated, the implications of the results show that ultrasound, together with the methods introduced in this work, would be better used to determine some of the acoustic properties of other materials.