Proceedings of the 3rd World Congress on Momentum, Heat and Mass Transfer (MHMT'18)
Budapest, Hungary – April 12 - 14, 2018
Paper No. ICMFHT 105
DOI: 10.11159/icmfht18.105

Interpreting the stability and Longevity of Bulk Nanobubbles

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Extended Abstract

Bulk nanobubbles are a novel revolutionary class of bubbles. They pose many challenges to our understanding of bubble physics and behaviour, yet a wide range of industrial applications have already been suggested including surface cleaning, drug delivery, ultrasound imaging, tissue preservation and food flavour retention. Based on Epstein-Plesset theory, the lifetime of bulk nanobubbles should be of the order of microseconds, but we experimentally confirm here rare reports that these nanobubbles display long term stability. Such an extraordinary longevity has not been explained, however, and has, thus, generated a fair amount of controversy in the literature about the origin and existence of bulk nanobubbles. In this study, suspensions of bulk nanobubbles were produced in water, and a technique which indirectly tracks nanoparticles and analyses their Brownian motion in real time was used to visualise the nanobubbles and measure their size distribution and number concentration. The typical number concentration was 1.5×10^8–2.2×10^8 bubbles/mL and the Sauter mean diameter was 90–130 nm. The stability of the nanobubble suspensions was monitored over a period of 3 months. Whilst the number density decreased gradually over time, the Sauter mean diameter remained constant, thus suggesting the absence of bubble coalescence, breakup and Ostwald ripening. We show that these nanobubbles enjoy another peculiar property which is the existence of a considerable negative charge on their interface. Based on the results obtained, we propose, for the first time, a rational explanation for the longevity of bulk nanobubbles.