Ultrasound-induced inertial cavitation by Zinc Oxide Nanocrystals

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Nanoparticles able to promote inertial cavitation when exposed to focused ultrasound have recently gained much attention due to their vast range of possible applications in the biomedical field, such as enhancing drug penetration in tumor, supporting ultrasound contrast imaging or cancer therapy. Due to their nanometric size, these contrast agents could penetrate through the endothelial cells of the vasculature to target tissues, thus enabling more effective therapeutic effects and higher imaging resolutions than commercial gas-filled microbubbles. Herein, biocompatible and bio-degradable Zinc Oxide NanoCrystals (ZnO NCs), opportunely functionalized with amino-propyl groups, are developed as novel nanoscale cavitation-inducing agents. Custom flow-through gel phantoms have been developed to characterize the acoustic response of the nanocrystals flowing in water solutions inside sub-millimiter channels. Passive cavitation detection technique and high-speed camera observations revealed that ZnO NCs are able to induce inertial cavitation when exposed to single 100-cycles pulses with Peak Rarefactional Pressure higher that 1.4 MPa. Bubble dynamics obtained by high-speed camera suggest that gas pockets trapped at the surface of ZnO NCs are able to grow and detach from the NC surface, reaching bubble radii between 4 and 8 μm. Together, these data show great potential for the application of the novel nanoscale agent to the theranostic and drug delivery fields.

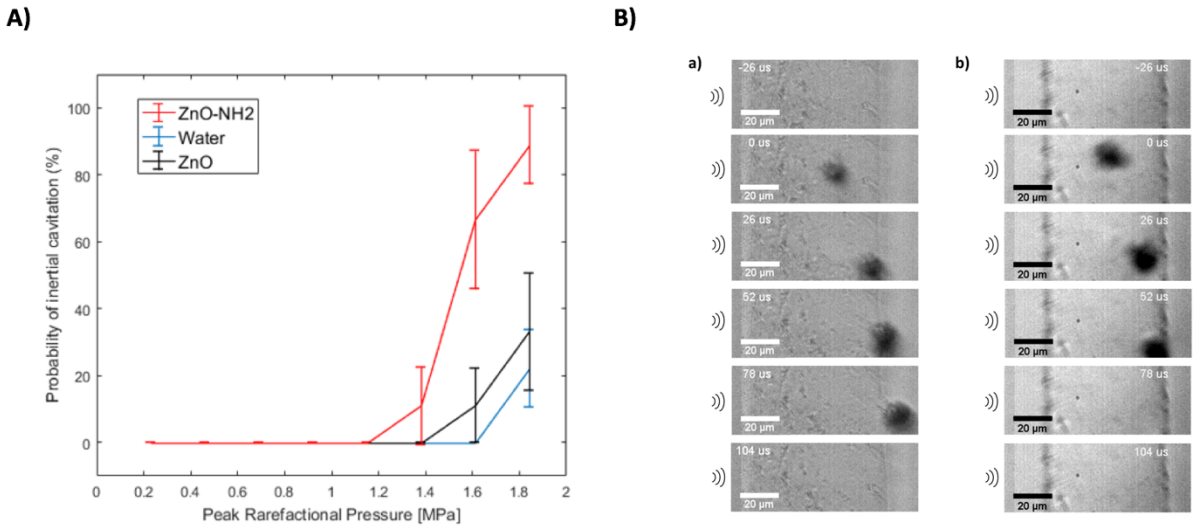

Figure 1. A) Probability of inertial cavitation for ZnO, ZnO-NH_2 NCs and water solutions when exposed to a single 1 MHz ultrasound pulse of 100 cycles. (n=3) B) Representative image time series of cavitation events generated by ZnO-NH_2 NCs when exposed to a single 1 MHz ultrasound pulse of 100 cycles at PRP = 1.6 MPa. Exposure time = 3 μsec, Frame period = 26 μsec. Time = 0 μsec represents time of arrival of the ultrasound pulse at the sample.

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