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Finite difference time domain numerical simulation of ultrasonic propagation in coated contrast agents

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Acoustic wave propagation in solutions of ultrasound contrast agents (UCA) designed for in situ drug delivery remains unclear due to the complex interaction between ultrasound and the coated particles (mode conversion, scattering, multiple reflections). To address this problem, two-dimensional Finite Difference Time Domain numerical simulations of ultrasound transmission and reflection were performed in solutions of an aqueous suspension of spheres made of fluid surrounded by a polymeric capsule. Simulations were made for particle concentrations equivalent ranging from 2 to 87 mg/ml. For each concentration 15 aqueous solutions with randomly located particles were considered. The speed of sound c, the attenuation coefficient and the integrated backscattered coefficient were computed from the transmitted and backscattered signals. The values of c decrease from 1498 m/s to 1432 m/s when the concentration increases, in good agreement with an effective medium model. The attenuation coefficient at 5 MHz is an increasing function of the concentration, from 0.05 to 1.2 dB/cm. The integrated backscattered coefficient increases with the concentration for low concentration values but decreases for high concentration (with a maximum value for a concentration of about 50 mg/ml). Our numerical simulations successfully mimic experimental results of ultrasound propagation in solutions of UCA.