Bubble dynamics-driven control of local microstructure in colloidal gels using ultrasound

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The microstructure of colloidal gels determines their rheological response and is therefore critical in applications such as battery electrode slurries, personal care and food products. We demonstrated [1] that ultrasound-driven, confined microbubbles induce particle bond alignment along specific orientations (±π/4), similar to those observed under oscillatory shear at 70 Hz [2]. The mechanism causing this orientational order is not fully understood, but structures appear normal to the velocity plane. To elucidate the origin of ±π/4 orientational order, we complement particle-resolved confocal microscopy with flow visualisation. The model colloidal gel used in confocal microscopy experiments consists of fluorescent PMMA dispersed in squalene with linear polybutadiene as polymer depletant. Microbubbles are embedded in the gel in a confined, quasi-2D geometry. We drive the bubbles into volumetric oscillations with ultrasound at 10-100 kHz. The locally ordered microstructure (Figure 1, left) is characterised using a previously introduced order parameter that captures the local bond orientation around the bubble [1]. Using a dilute suspension of charge-stabilised latex particles, flow visualisation with brightfield microscopy reveals the secondary flow caused by the confined bubble oscillations (Figure 1, right), which is found to vary with bubble confinement. The combination of microstructure characterisation and flow visualisation supports the hypothesis that the distinctive ±π/4 orientational order is caused by the flow component normal to the observation plane. This finding opens a new avenue for the use of ultrasound as a tool to control the microstructure of colloidal gels in industrial processes.

Keywords:
colloidal gels, flow-induced structuring, orientational order, ultrasound, oscillating microbubbles

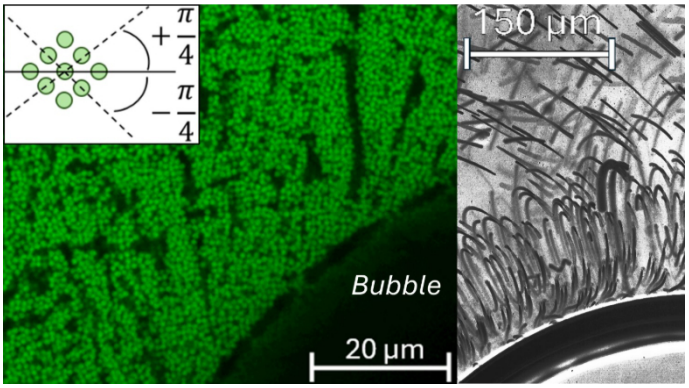

Figure 1. Left: Confocal microscopy image of the colloidal gel after ultrasound exposure showing square-like structural order (inset). Right: Brightfield flow visualisation revealing toroidal vortices near the bubble.

References:

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