Tuning vaporization thresholds of endoskeletal perfluorocarbon droplets

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Background, Motivation and Objective

Perfluorocarbon droplets have been extensively used as phase-change contrast agents for biomedical ultrasound imaging. The phase-change behavior of these droplets is governed by their intermolecular forces. Several studies have aimed at understanding the vapor embryo nucleation and vaporization behavior of these droplets. However, these studies largely use the critical temperature of the pure fluorocarbon species to tune phase-change behavior and have not looked at tuning of the thermodynamic limit of stability (spinodal) by using heterogeneous mixtures. Controlling the spinodal by altering the intermolecular forces of the volatile mixture may allow better control over the phase-change behavior.

Statement of Contribution/Methods

We investigated the vaporization behavior of different fluorocarbon and hydrocarbon mixtures. Solid alkanes (ranging from 18- to 24- carbon chain length) were used with perfluoropentane as the volatile liquid to make endoskeletal (solid-in-liquid) droplets. Vaporization of these endoskeletal droplets were tested over a range of temperatures. The tests results were verified both optically using a microscope as well as acoustically using a clinical ultrasound scanner.

Results/Discussion

Surprisingly, we show that the endoskeletal droplets vaporized near the melting point of the solid hydrocarbon phase. We were thus able to vary the vaporization temperature of the droplets from 23 °C to 45 °C depending on the hydrocarbon species used. Using a simple statistical thermodynamics lattice model, we demonstrate that the presence of the hydrocarbon breaks the intermolecular attraction between the fluorocarbon molecules, making it possible to finely tune its spinodal and consequently the vaporization temperature.

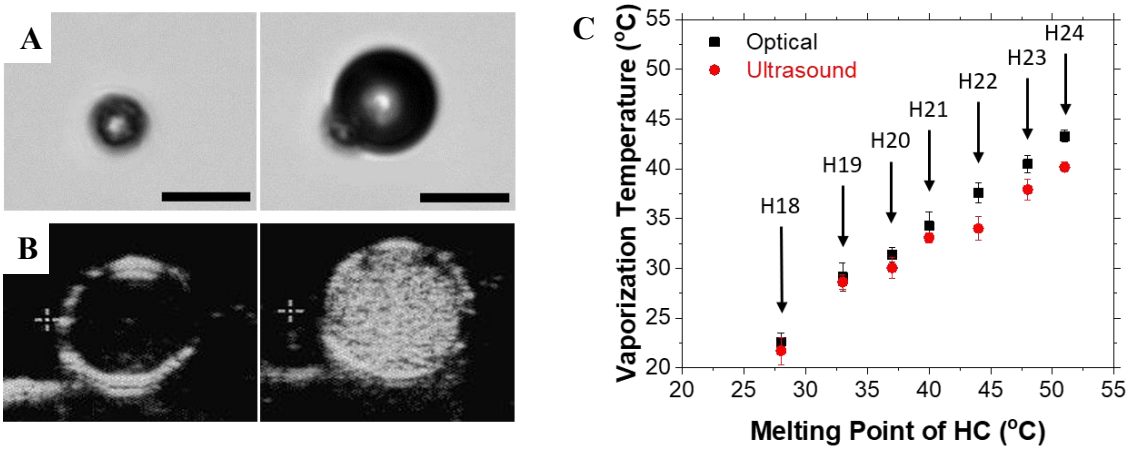

Figure 1 | A Optical microscopic image of a droplet before and after vaporization. Scale bar 20 µm. **B** Contrast-enhanced ultrasound image of the droplet solution inside dialysis tubing before vaporization and after vaporization of the droplets. **C** Linear correlation of the vaporization temperature of endoskeletal droplets and the melting point of the solid hydrocarbon.