Supporting Information: Polypyrrole Coated Perfluorocarbon Nanoemulsions as a Sono-Photoacoustic Contrast Agent

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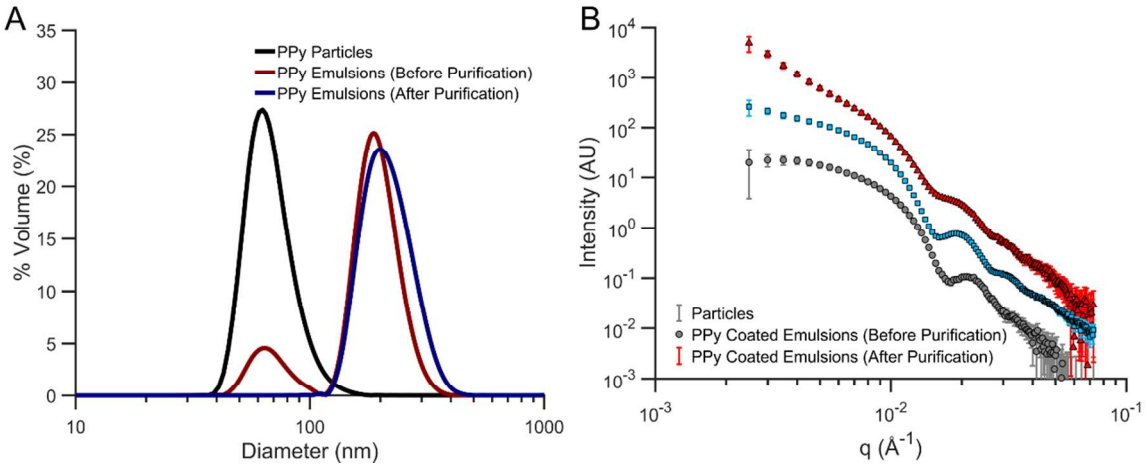

Figure S1: Alterations in (B) size distribution of the samples and (B) small-angle X-ray scattering (SAXS) profiles due to particle separation through centrifugation. Polypyrrole (PPy) emulsion samples after synthesis have an excess of PPy particles (no perfluorocarbon core). The excess particles can be separated from emulsions due to the density different of the emulsions and the PPy particles. After multiple centrifugation and resuspension steps, the emulsions can be isolated (see panel A). The role centrifugation has in isolating the emulsions from excess particles is also seen in the SAXS data. The turn over in slope to zero for the particle samples in the low-q region ($q < 0.006$ Å^{-1}) is indication of individual particles in the pure PPy particle sample. The emulsion samples before centrifugation show have a similar scattering pattern to the particles. However, the shallow negative slope in the low-q region is a clue indicating that a larger structure exists in the sample. This is verified in the scattering pattern of the emulsion sample after centrifugation.

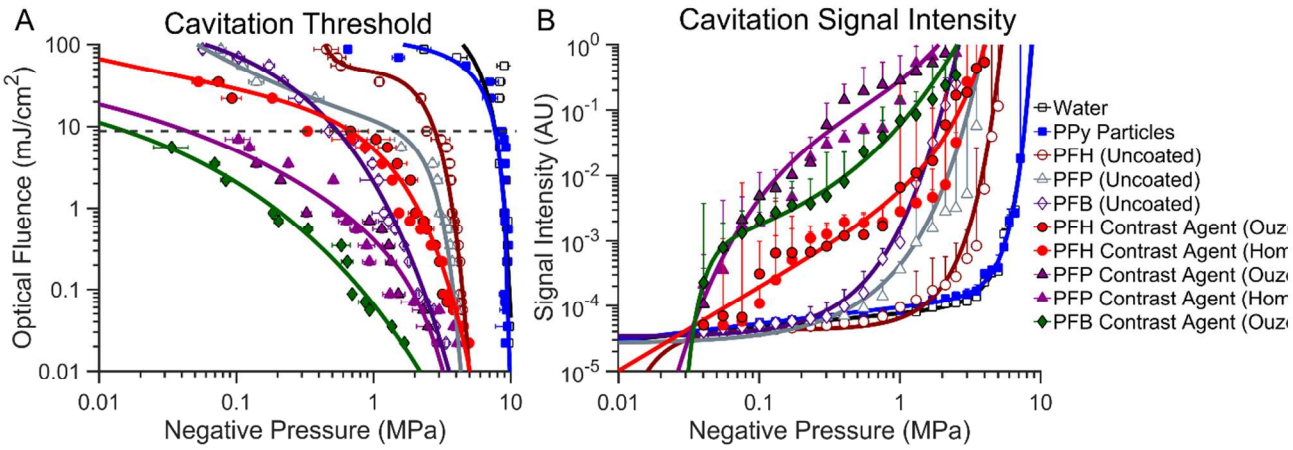

Figure S2: (A) SPA activation (cavitation) threshold using 1.24 MHz acoustic and 1064 nm optical pulses. (B) Representative cavitation signal intensity at 9 mJ/cm^2. Cavitation of PPy emulsion contrast agents creates transiently oscillating perfluorocarbon bubbles that can be used for contrast enhanced imaging or therapy. The cavitation (or activation) thresholds for the PPy emulsion contrast agent are significantly lower than those for water, PPy particles (no PFC core), and uncoated droplets with identical core materials. The cavitation threshold for PPy emulsions reduces as lower boiling point PFCs are used as the core material. No significant differences in cavitation threshold and intensity were seen using PPy emulsions of the same PFC core but different emulsification methods (i.e. homogenization versus ouzo nucleation).

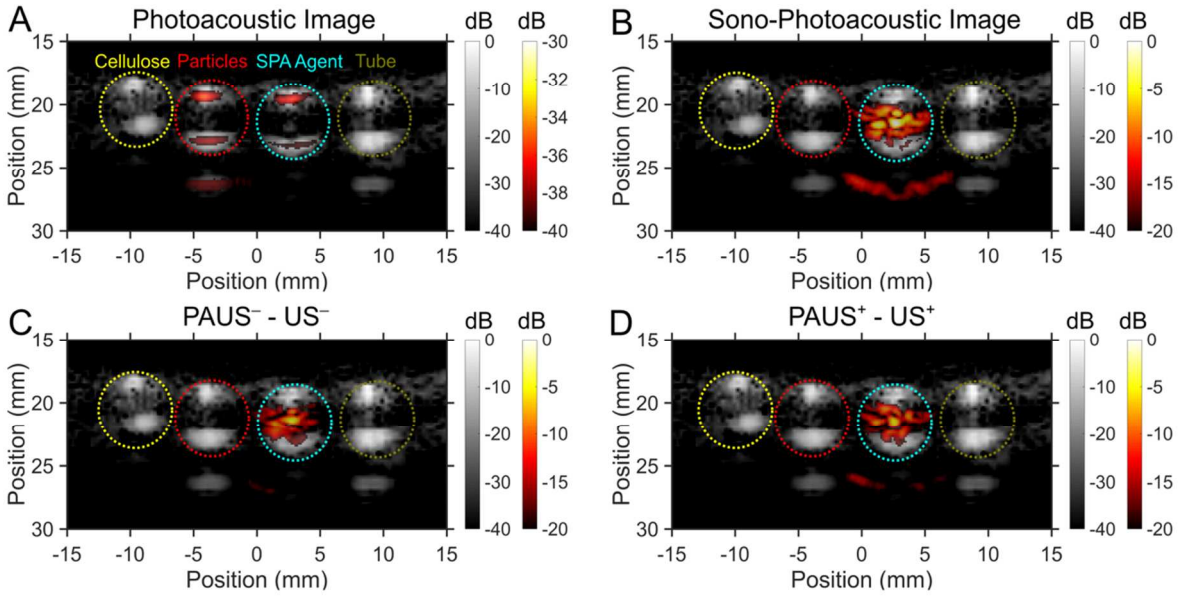

Figure S3: (A) Photoacoustic image versus (B) Sono-photoacoustic image. The sono-photoacoustic image is reconstructed using frames C and D with equation 1 described in the methods. Although the PAUS-US images (panels C and D) show contrast enhancement within the tube containing the SPA agent, a linear photoacoustic signal is still seen in the photoacoustic particle containing tube as well as the interface of the SPA agent containing tube. After taking the difference between panels C and D, linear photoacoustic signals are removed, isolating the non-linear sono-photoacoustic signals generated from vaporizing droplets (panel B).

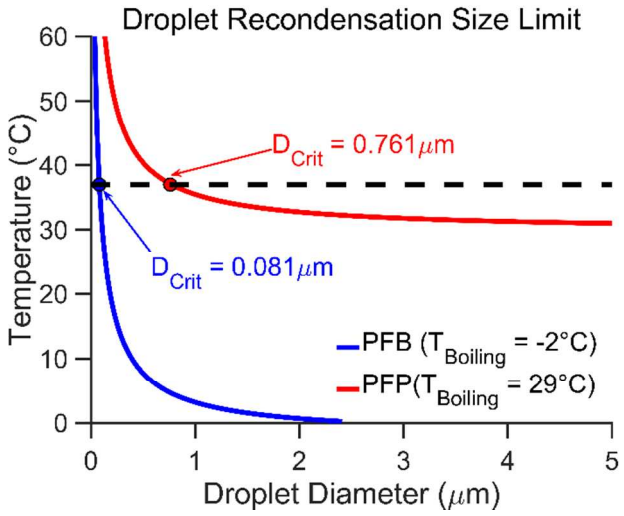

Figure S4: The limit for droplet activation and recondensation can be estimated from the vapor-liquid pressure-temperature phase transition limit of perfluorobutane (PFB) and perfluoropentane (PFP). The estimate of critical droplet diameter can be used to define the maximum droplet diameter that once vaporized will recondense due to Laplace pressure contributions. The estimate is obtained using the ideal gas law and interfacial properties of the perfluorocarbons to determine for any given vaporized droplet diameter if it will recondense or remain a stable bubble. Stability of the droplet follows an 1/r trend, asymptoting at the bulk boiling point for each respective fluid. For PFB and PFP, the critical diameter for a recondensable droplet at body temperature is 81 nm and 761 nm in diameter, respectively. Perfluorohexane (PFH) was not plotted because its boiling point ($T_{boiling}$ = 56°C) is well above body temperature, guaranteeing that SPA vaporized PFH droplets will recondense.

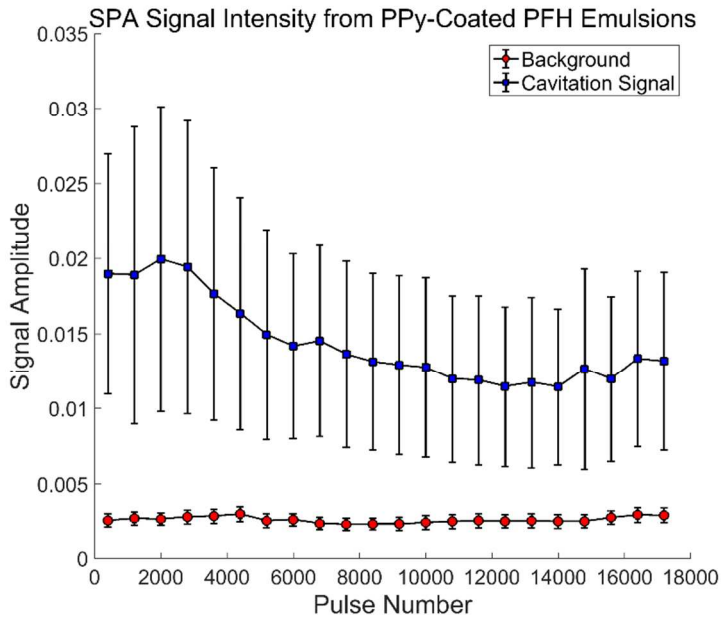

Figure S5: Sono-photoacoustic (SPA) signal decay when exposing PPy-coated PFH to multiple activation events. All measurements were taken using an acoustic pressure of 1.87 MPa (MI = 1.67) and an optical fluence of 7.6 mJ/cm^2 in a water bath held at body temperature (37°C) using the SPA setup illustrated in figure 3A. The averaged signal amplitude shows little change even after ten thousand pulses. Even though almost no decay in signal amplitude was observed, we periodically flushed the sample holder with degassed DI water every 6000 shots before continuing with measurements.