P.16 Bicontinuous emulsions stabilized by nanoparticles

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Bicontinuous interfacially-jammed emulsion gels (bijels) are a relatively new class of versatile soft materials with a number of possible technological applications including tissue engineering, materials templating, fuel cells and microfluidics. They are produced by arresting the spinodal decomposition of a binary liquid mixture using neutrally-wetting colloidal particles which sequester to the liquid-liquid-interface, resulting in two tortuous interlocking channels (see Figure 1). Initially predicted by simulation in 2005[1] and subsequently realised experimentally in 2007[2], open questions regarding the formation of bijels and their long-term stability remain.

For various applications, smaller channels than the typical tens of microns (achieved using micron-sized particles) would be advantageous. Channel width L should scale as $\sim r/\varphi$, where r is the particle radius and φ the particle volume fraction[3]. Hence, nanoparticles could be used to achieve the reduction in pore size. However, simulations suggest that nanoparticle-stabilised bijels may not necessarily be stable at long timescales, since the particle attachment energy scales with r^2.

Here we show that by using nanoparticles we can reduce the channel width approximately fivefold at constant volume fraction. Stöber silica spheres are used to stabilise a bijel of the binary pair water and 2,6-lutidine, the structure of which appears stable over many weeks. Like the bijels made with micron sized particles, a 'monogel' is formed, so that the interfacial layer of nanoparticles remains intact after the remixing of the two liquids[4], which also allows post-processing into bicontinuous polymer-air composites[5].

Unlike their larger counterparts, the use of nanoparticles has mediated the use of much slower quench rates during the bijel preparation, from a minimum rate of 17°C/min down to as low as 1°C/min. Also, the prefactor in the scaling relationship $L \sim Cr/\varphi$ has increased, implying a lower interfacial uptake of particles. These results raise questions about the kinetics of binary liquid phase separation in the presence of colloidal particles of varying sizes.

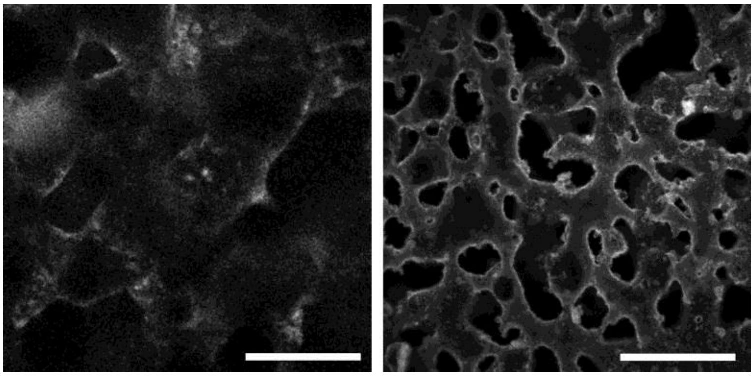

Figure 1. Confocal micrographs of bijels stabilized by (left) 250 nm and (right) 80 nm radius silica particles (white). Scale bar: 100 micron.

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