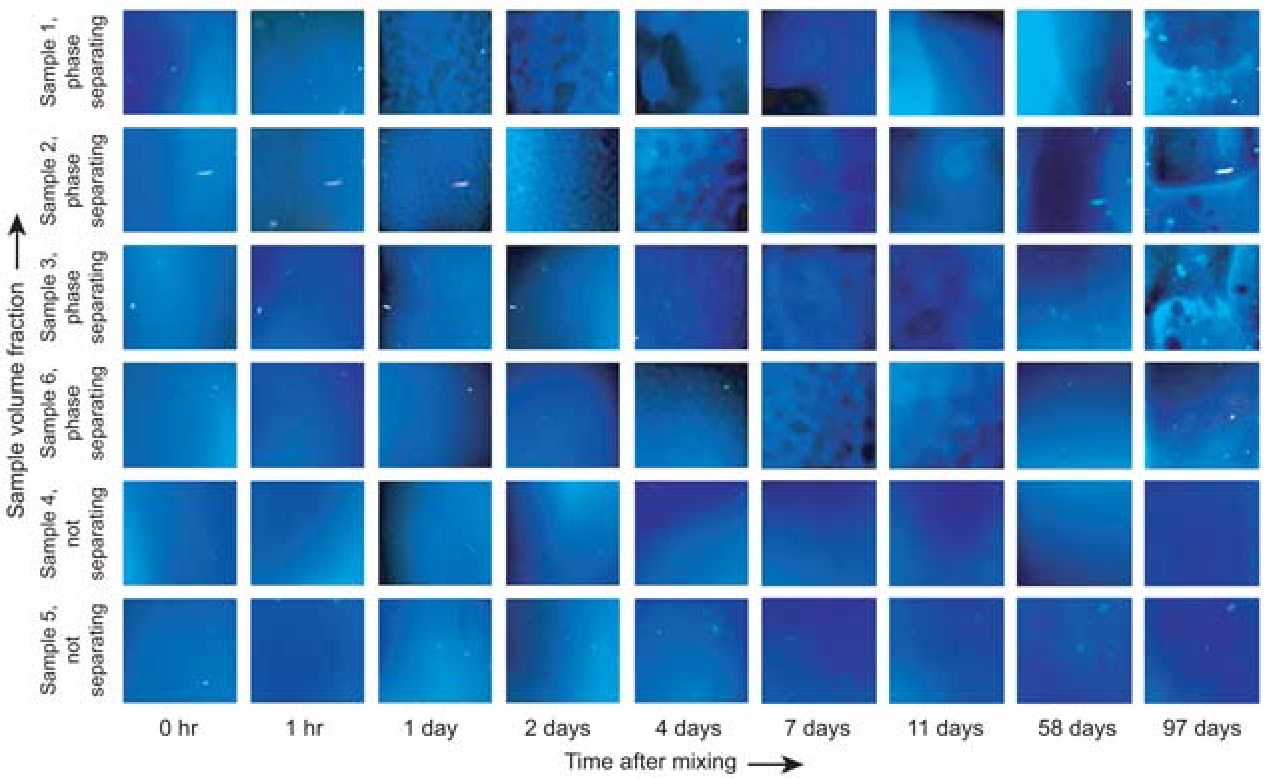
Binary Colloidal Alloy Test-3 (BCAT-3) Tabletop Space Station Experiment Continues

"As above, so below," thus begins the Emerald Tablet that was inscribed in 300 B.C., long before we could look into the heavens and see a space station that might serve as a platform for exploring other worlds and for exploring the natural ways that order arises out of chaos. To raze the ancient intent of this quote (and lift it out of context), we note that the effects of gravity would be balanced (removed) at the center of the Earth (below) and that this is also the case aboard the International Space Station (above). Yet, those of us on Earth are caught in the middle, where the effects of gravity are profound and disturbing for observers wanting to study nature's self-organizing tendencies, tendencies that are masked by sedimentation and convection on Earth.



BCAT–3 critical point samples 1 through 6 evolving in microgravity. Colloidal/polymer mixtures that are near the critical point are already starting to phase separate into two components: a colloid-rich phase (blue areas) and a colloid-poor phase (black areas). The quickly changing dynamic data captured in these photographs will help determine the boundary conditions for future models of critical behavior. The present observations include a determination of the shape of the interface and reveal which part of each sample wets the cell. The long-term observation of which samples phase separate will

allow us to precisely determine the critical point of this colloidal mixture.
Long description of figure. BCAT-3 samples (varying volume fractions) versus time in microgravity after mixing. The widths of the continuous blue regions in these photographs show how much the sample has phase separated. It coarsens and grows as the phase separation proceeds. It looks like we can actually visualize phase separation in microgravity from the beginning.

For NASA principal investigators from Harvard (David Weitz and Peter Lu) and the University of Pennsylvania (Arjun Yodh and Jian Zhang), an orbiting space experiment (launched Jan. 2004) using small colloidal particles in a fluid revealed the progress of these organizing tendencies at a pace that can be captured by astronauts with a camera. Once colloidal particles are mixed in a fluid (randomized) and begin to order themselves, photographs can capture the knowledge we are after in the form of beautiful blue and dark brown images of the Binary Colloidal Alloy Test-3 (BCAT-3) experiment (see the first 6 of 10 test tube images in the preceding figure). Samples 1 through 6 for this experiment were created to cover a range of concentrations that allow David Weitz and Peter Lu to determine where the critical point is for these mixtures. This is akin to the critical point for a liquid-gas mixture: where the liquid and gas phases are no longer distinguishable. Knowledge about critical points has engineering applications (e.g., in extracting caffeine from coffee beans or magnesium from rocks on Mars to make rocket fuel) and also provides fundamental knowledge that helps us to understand how the material world operates.

Other samples in the BCAT-3 experiment use weak concentrations of similar particles that also are only about 1/100 the diameter of a fine human hair. Arjun Yodh and Jian Zhang use these samples to grow surface crystals composed of particles with sizes comparable to the wavelength of light. Ordered arrays of such particles might be ideal for switching and controlling light. Early results from this ongoing experiment are modifying our understanding of the theory used to predict when surface crystals will grow in an ideal environment where gravity is absent. The BCAT-3 experiment is finding that nature can reveal much more in the heavens than on Earth.

Find out more about this research:
BCAT-3 at http://microgravity.grc.nasa.gov/6712/comflu/bcat3.html
Experimental Soft Condensed Matter Group at
http://www.deas.harvard.edu/projects/weitzlab/
Experimental Condensed-Matter Physics (link to lab page) at
http://dept.physics.upenn.edu/facultyinfo/yodh.html

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