Acronym: BCAT-5-3D-Melt

Payload Title: Binary Colloidal Alloy Test - 5: Three-Dimensional Melt

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Developer(s): Glenn Research Center, Cleveland, OH
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Sponsoring Agencies: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 19, 20

Mission Assigned: N/A

Brief Research Summary (PAO): Binary Colloidal Alloy Test - 5: Three-Dimensional Melt (BCAT-5-3D-Melt) photographs initially randomized colloidal samples in microgravity to determine their resulting structure over time. BCAT-5-3D-Melt will allow the scientists to capture the kinetics (evolution) of their samples, as well as the final equilibrium state of each sample. BCAT-5-3D-Melt will look at the mechanisms of melting using three-dimensional temperature sensitive colloidal crystals. Results will help scientists develop fundamental physics concepts previously shadowed by the effects of gravity.

Research Summary:

- Binary Colloidal Alloy Test - 5: Three-Dimensional Melt (BCAT-5-3D-Melt) is one of four investigations in the BCAT-5 suite of experiments. BCAT-5-3D-Melt utilizes sample 10 in the BCAT-5 hardware.

- BCAT-5-3D-Melt takes advantage of the microgravity environment on the ISS to prevent the colloidal particles in these samples from encountering sedimentation, convection, and gravitational jamming utilizing temperature-sensitive polymers and microgel particles to tune soft matter through melting and crystallization transitions.

- The BCAT-5-3D-Melt documents changes in particle size and sample volume fraction which cause the sample to move in and out of the crystalline regime during International Space Station (ISS) cabin temperature changes over a two-week period.

Detailed Research Description: The Binary Colloidal Alloy Test - 5 (BCAT-5) hardware supports four investigations. Samples 1 - 5, the Binary Colloidal Alloy Test - 5: Phase Separation (BCAT-PhaseSep) will study collapse (phase separation rates that impact product shelf-life). In microgravity the physics of collapse is not masked by being reduced to a simple top and bottom phase as it is on Earth. Samples 6 - 8, Binary Colloidal Alloy Test - 5: Compete (BCAT-5-Compete) will study the competition between phase separation and crystallization, which is important in the manufacture of plastics and other materials. Sample 9, Binary Colloidal Alloy Test - 5: Aspheres (BCAT-5-Aspheres) will study the properties of concentrated systems of small particles when they are identical, but not spherical; this could impact how light bends with angle and crystal orientation, strength, temperature transfer as a function of direction, *etc.*

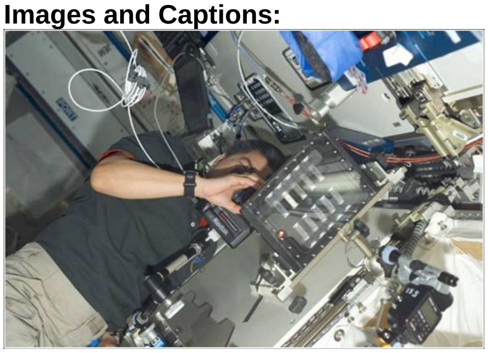
Sample 10, Binary Colloidal Alloy Test - 5: Three-Dimensional Melt (BCAT-5-3D-Melt) will look at the mechanisms of melting using 3 dimensional temperature sensitive colloidal crystals.

The BCAT-5-3D-Melt sample will consist of a monodisperse nearly-hard-sphere colloidal suspension near its crystallization point. For this investigation small temperature changes that decrease particle volume fraction will move the equilibrium system towards and away from the melting transition. The key ingredient in these samples is a thermosensitive polymer, poly(N-isopropylacrylamide (NIPA); the temperature-sensitive character of the samples stems from the temperature dependent solubility of NIPA polymer in water. Below its theta temperature (the temperature at which the coiled polymer molecules expand to their full contour lengths and become rod-shaped) of approximately 31 degrees C, water is a good solvent and NIPA polymer assumes a swollen coil form; in this regime a small increase of temperature increases monomer-monomer attractions and thus the size of the isolated polymer decreases. Above the theta temperature, water is a poor solvent and NIPA has a collapsed globule form.

The BCAT-5-3D-Melt experiment will simply record sample temperature and observe (by photography) whether the samples crystallize and at what temperatures the samples experience the fluid-solid transition. This information will be useful for planning future experiments planned for ISS.

Project Type: Payload

Images and Captions:



Astronaut Dan Tani photographing the BCAT-3 Sample Module using his own design for a ceiling mount in Node 2 of the International Space Station. Great high contrast pictures of difficult-to-capture images resulted from using this setup (February 2008).

Operations Location: ISS Inflight

Brief Research Operations:

- BCAT-5 consists of ten different individual sample cells. Binary Colloidal Alloy Test - 5: Three-Dimensional Melt (BCAT-5-3D-Melt) uses sample cell 10.

- Crewmembers will homogenize the samples and will look for crystals at various lighting angles. The crystals will be manually photographed and these photos downlinked allowing immediate feedback from scientists to the crewmembers.

- If crystals are found, the camera and lighting will be positioned at an angle that best captures this and the samples will be re-homogenized and a new round of photographs will be taken using EarthKAM automated photography over a period of 2 weeks. This will capture the kinetics of crystal formation.

- After photography, the samples are stowed and left undisturbed to allow for the continued growth of the colloidal structure for up to 6 months.

Operational Requirements: The BCAT-5 experiment consists of ten small samples of colloidal particles. The ten BCAT-5 samples are contained within a small case the size of a school textbook. The experiment requires a crewmember to set up on the Maintenance Work Area (MWA) or on a handrail/seat track configuration. Initially the sample will require manual photographs to be downlinked by astronaut to investigators on the ground for analysis. Following configuration confirmation from investigators the automated EarthKAM software will be setup to take digital photographs of samples at close range using the onboard Kodak DCS760 camera. Camera Control Files for running the EarthKAM software can be uploaded from Earth to control the photography intervals (how many photographs per hour) and spans (run for how many days) once it is running. The pictures are downlinked to investigators on the ground for analysis.

Operational Protocols: A crewmember sets up the video camera and BCAT-5 hardware (Slow Growth Sample Module, DCS760 Camera, pen-light source, flash and SSC Laptop with EarthKAM software) in the Maintenance Work Area (MWA) to document the BCAT-5 operations as performed on-board the ISS. The crewmember homogenizes (mixes) the sample(s) and takes the first photographs manually. This helps them optimize the setup and shows that the samples were initially fully homogenized when publishing results later. The EarthKAM software automates the rest of the photography session over a few days to 3-week period. The crewmember performs a daily status check once a day (when time is available) to assure proper alignment and focus. At the completion of the run, the crewmember tears down and stows all hardware.

Category: Physical Sciences in Microgravity

Subcategory: Materials Sciences

Space Applications: BCAT-5 will ultimately impact our understanding of the strength and thermal conductivity of materials by providing insight into the effects of size variation in dense suspensions of particles. For example, the careful selection of crystallization promoters for controlling the crystallite size and size distribution may lead to improvement in materials fabrication processes. The suppression of crystal nucleation in polydisperse colloids has important implications for the morphology of polycrystalline materials.

Earth Applications: BCAT-5 will evolve the field of colloidal engineering, which creates materials with novel properties using colloidal particles as precursors. To piece together answers to the scientific puzzles being studied, BCAT-5 takes advantage of the microgravity environment on the ISS to prevent the colloidal particles in these samples from encountering sedimentation, convection, and gravitational jamming.

Manifest Status: Reserve

Supporting Organization(s): Exploration Systems Mission Directorate (ESMD)

Previous Missions: The predecessors to BCAT-5, BCAT-3 and BCAT-4 are in operation on the ISS.

Results: N/A

Related Publications:

Islam MF, Nobili M, Fangfu Ye, Lubensky TC, Yodh AG. Cracks and Topological Defects in Lyotropic Nematic Gels. *Physical Review Letters. 2005;* 95:148301.

Alsayed AM, Islam MF, Zhang J, Collings PJ, Yodh AG. Premelting at defects within bulk colloidal crystals. *Science. 2005;* 309:1207-1210.

Alsayed AM, Dogic Z, Yodh AG. Melting of lamellar phases in temperature sensitive colloid-polymer suspensions. *Physical Review Letters. 2004;* 93, 057801-1 - 057801-4.

Islam MF, Alsayed AM, Dogic Z, Zhang J, Lubensky TC, Yodh AG. Nematic nanotube gels. *Physical Review Letters. 2004;* 92, 088303-1 - 088303-4.

Web Sites:
Binary Colloidal Alloy Test - 3 (BCAT-3)
http://exploration.grc.nasa.gov/life/bcat3_iss.html

Related Payload(s): BCAT Investigations, EXPPCS.

Last Update: 10/10/2008