Acronym: BCAT-5-PhaseSep

Payload Title: Binary Colloidal Alloy Test-5: Phase Separation

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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): The Binary Colloidal Alloy Test - 5: Phase Separation (BCAT-5-PhaseSep) experiment will photograph initially randomized colloidal samples onboard the ISS to determine their resulting structure over time. This allows the scientists to capture the kinetics (evolution) of their samples, as well as the final equilibrium state of each sample. BCAT-5-PhaseSep studies 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.

Research Summary:

- The BCAT-5 hardware consists of ten different individual sample cells comprising 4 investigations. For the Binary Colloidal Alloy Test - 5: Phase Separation (BCAT-5-PhaseSep) samples 1 - 5, crewmembers photograph samples of polymer and colloidal particles (tiny submicron size spheres suspended in liquid) that model liquid/gas phase changes. Results will allow scientists to see some of the fundamental physics concepts that are behind product collapse; these observations have been cloaked by the effects of gravity.

- The BCAT-5-PhaseSep samples will be formulated using key components found in products like Downy™. Many such products require expensive additives to ensure that collapse does not occur during the stated shelf-life. A fundamental understanding of the underlying physics that is needed to stabilize these everyday products may enable a formulation with enhanced performance and stability, while simultaneously lowering the cost of manufacture.

- Crewmembers on board the ISS set up the BCAT-5 experiment and use a camera to take pictures of all of the samples as they evolve in time. This is done both manually and with ISS Earth Knowledge Acquired by Middle School Students (EarthKAM) software which automates imagery capture.

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 three-dimensional temperature sensitive colloidal crystals.

BCAT-5-PhaseSep is a follow-on experiment to Binary Colloidal Alloy Test -3 - 4: Critical Point (BCAT-3-4-CP) investigation, which began on increment 8. Fabric enhancers are composed of mixtures of vesicle and polymers which, in some cases, form weak particle gels. These gels often coarsen exhibiting sintering, cracking or collapse, which significantly reduce the product shelf life. The factors that contribute to coarsening are enigmatic, as the processes are often concealed by the gravitational compression of the gel. Microgravity experiments offer a unique opportunity to elucidate coarsening mechanisms in these weak gel systems.

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. BCAT-5: Phase Separation (BCAT-5-PhaseSep) samples utilize sample cells 1 - 5.

- Crewmembers will homogenize these samples and photograph one sample at a time, to capture the rate of phase separation in the samples using EarthKAM automated photography software over a period of 1 - 3 weeks per sample. Images will be downlinked to allow scientists to provide immediate feedback to the crewmembers onboard the ISS.

- 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, ISS Laptop and utilize EarthKAM software to take digital photographs of Samples 1 - 8 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. Samples 6 - 10 will follow the same process but will also initially require manual photographs taken by the crewmember. 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 period of a few days to a few weeks. 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: This experiment addresses basic physics questions, but some of the areas may eventually have applications for space exploration. Supercritical fluids, which are one of the applications of the phase separation experiment, are of potential application in propulsion systems for future spacecraft design.

Earth Applications: These samples will provide important data that is not available on Earth; data that can guide our understanding of phase separation (*e.g.*, shelf-life, product collapse), and how it competes with crystallization to impact production (*e.g.*, when making plastics).

Manifest Status: Reserve

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

Previous Missions: BCAT-3, the predecessor to BCAT-5, began operation on ISS during Increment 8. BCAT-4 began operation during Increment 17.

Results: N/A

Results Publications: N/A

Related Publications:

Lu PJ, Zaccarelli E, Ciulla F, Schofield AB, Sciortino F, Weitz DA. Gelation of particles with short-range attraction. Nature. 2008; 453:499-503.

Huh J, Lynch M, Furst E. Microscopic structure and collapse of depletion-induced gels in vesicle-polymer mixtures. Physical Review. 2007 ;E 76, 051409.

Bailey AE, Poon WCK, Christianson RJ, Scholfield AB, Gasser U, Prasad V, Manley S, Segre PN, Cipelletti L, Meyer WV, Doherty MP, Sankaran S, Jankovsky AL, Shiley WL, Bowen JP, Eggers JC, Kurta C, Lorik, Jr. T, Pusey PN, Weitz DA. Spinodal Decomposition in a Model Colloid-Polymer Mixture in Microgravity. Physical Reveiew Letters. 2007 ,November 16; 99:205701.

Lu PJ, Weitz DA, Foale CM, Fincke EM, Chiao L, McArthur WS, Williams JN, Meyer WV, Owens J Hoffmann MI, Sicker RJ, Rogers RB, Frey CA, Krauss AS, Funk GP, Havenhill MA, Anzalone SM, Yee HL, Science Applications International Corporation, Microgravity Phase Separation Near the Critical Point in Attractive Colloids, Proceedings of the 45th Aerospace Sciences Meeting and Exhibit. 2007; AIAA-2007-1152.

Gopalakrishnan V, Schweizer KS, Zukoski CF. Linking single particle rearrangements to delayed collapse times in transient depletion gels. Journal of Physics-Condensed Matter. 2006, December 20; 18 (50): 11531-11550.

Manley S, Skotheim JM, Mahadevan L, *et al.* Gravitational collapse of colloidal gels, Physical Review Letters. 2005, June 5;94 (21): Art. No. 218302.

Blijdenstein TBJ, van der Linden E, van Vliet T, *et al.* Scaling behavior of delayed demixing, rheology, and microstructure of emulsions flocculated by depletion and bridging, Langmuir. 2004, December 21;20 (26): 11321-11328.

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Web Sites:

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

Experimental Soft Condensed Matter Group
http://www.deas.harvard.edu/projects/weitzlab/index.html**,**

Related Payload(s): BCAT Investigations, EXPPCS.

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