Acronym: BCAT-5-Compete

Payload Title: Binary Colloidal Alloy Test - 5: Compete

Principal Investigator:
Barbara Frisken, Ph.D., Simon Fraser University, Burnaby, British Columbia, Canada

Co-Investigators:
Arthur Bailey, Ph.D., Simon Fraser University, Burnaby, British Columbia, Canada
David Weitz, Ph.D., Harvard University, Cambridge, MA

Contacts:
Barbara J. Frisken, frisken@sfu.ca , (778) 782-5767 or (778) 782-5703;
Arthur E. Bailey, abailey@sfu.ca, (604) 982-0890
David A. Weitz, weitz@deas.harvard.edu, (617) 496-2842

Mailing Addresses:
Professor Barbara J. Frisken
Simon Fraser University
Department of Physics
8888 University Drive
Burnaby, B.C. V5A 1S6
Canada

Dr. Arthur E. Bailey
Simon Fraser University
Department of Physics
8888 University Drive
Burnaby, B.C. V5A 1S6
Canada

Professor David A. Weitz
Harvard University
Department of Physics
Pierce 231
Cambridge, MA 02138

Developer(s): NASA Glenn Research Center, Cleveland, OH
ZIN Technologies, Cleveland, OH

Sponsoring Agencies: National Aeronautics and Space Administration (NASA) and the Canadian Space Agency (CSA).

Increment(s) Assigned: 19, 20

Mission Assigned: N/A

Brief Research Summary (PAO): The Binary Colloidal Alloy Test - 5: Compete (BCAT-5-Compete) investigation will photograph andomized colloidal samples onboard the International Space Station (ISS) to determine their resulting structure over time. The use of EarthKAM software and hardware will allow the scientists to capture the kinetics (evolution) of their samples, as well as the final equilibrium state of each sample. BCAT-5-Compete will utilize samples 6 - 8 in the BCAT-5 hardware to study the competition between phase separation and crystallization, which is important in the manufacture of plastics and other materials.

Research Summary:

- The BCAT-5 hardware consists of ten different individual sample cells comprising 4 investigations. Binary Colloidal Alloy Test - 5: Compete (BCAT-5-Compete) utilizes three sample cells.

- Samples 6 - 8 will focus specifically on the effect of phase separation on crystal growth. On Earth, gravity causes the colloids to settle, making such a study particularly difficult. Performing these experiments in the microgravity environment of the ISS will allow scientists to study growth of much larger structures, and, thus, maximize the extent to which the behavior can be explored.

- Improved understanding of these processes will lead to more refined manufacturing processes and commercial products. The competition between a phase separation process and an order-disorder transition remains largely unstudied and offers an opportunity to observe some fascinating behavior. The overarching goal of all these experiments is to develop the key knowledge to help make colloidal engineering a reality. In addition, this experiment should help scientists understand the fundamental properties of colloid-polymer mixtures to further improve the commercial use of such systems.

- Crewmembers on board the ISS set up the BCAT-5 hardware and use a camera to take pictures of all the samples as they evolve in time. This is done both manually and with an ISS EarthKAM computer software.

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-Compete samples consist of colloids suspended in solvent with added polymer. By changing the amount of colloid and the relative amount of colloid and polymer, the equilibrium state of the sample can be changed. The BCAT-5-Compete samples will have equilibrium concentrations that result in mixtures of colloid-liquids, colloidal gas and colloidal crystal. The purpose of these experiments is to study the kinetics that lead to these unique solutions.

The samples will be mixed and are expected to take several days to reach a nearly equilibrium state. During this time the EarthKAM system will be used to take high-resolution photographs of the samples at regular intervals. As the phase separation/crystallization kinetics begin immediately after the samples are mixed, the interval between images should be relatively short. As the kinetics proceed, the time between images can be increased. Imaging such as this has been performed during BCAT-3 and BCAT-4. The downlinked images will be analyzed using standard techniques to measure the spatial size of concentration variations in the sample or sizes of crystallites as a function of time.

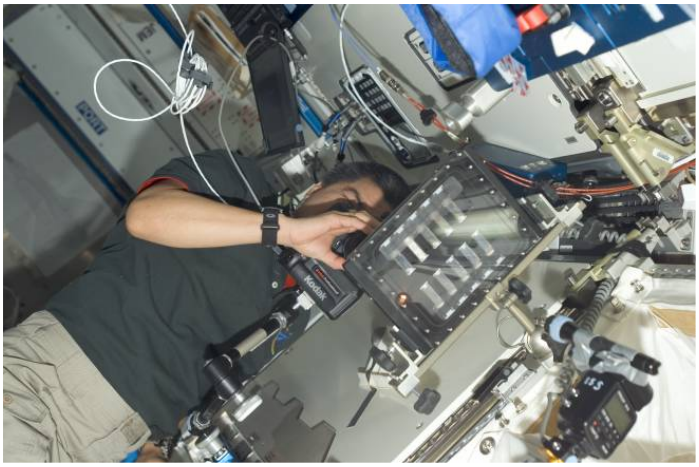
Because crystals may be present, the BCAT-5-Compete samples will likely require that the small flashlight be used to determine optimal lighting and repeat the EarthKAM system measurements in an effort to extract as much data as possible regarding the time dependence of crystallite formation.

Ultimately, the experiment is designed to determine if in samples which both phase separate and crystallize, if the dynamics of either process is affected by the other. For example, one possible scenario

might be that phase separation, which induces local density increases, reduces the crystallite initiation time because of the increased density increase. These systems are relatively unexamined and a wealth of new phenomena may be observed.

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-Compete samples make up three of the sample cells, samples 6 - 8.

- For BCAT-5-Compete: crewmembers will homogenize the samples and photograph one sample at a time, to capture the rate of phase separation in the samples using EarthKAM automated photography over a period of days to 3 weeks per sample.

- Crewmembers will occasionally check for crystals by looking for the presence of color at various lighting angles. If crystals are found, the camera and lighting will be positioned at an angle that best captures this and the samples will be rehomogenized and a new round of photographs will be taken using EarthKAM. During these procedures, images will be downlinked to allow scientists to provide immediate feedback to the astronauts.

- 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, which may form crystals, require manual photographs (at least initially) be taken by an 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 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-Compete addresses basic physics questions and how defects form when phase separation and crystallization compete.

Earth Applications: These samples will provide important data that is not available on Earth; data which can guide our understanding of crystallization to impact production (e.g., when making plastics). Production processes often have defects introduced when there is a competition with processes like phase separation and crystallization. Studying this competition in the absence of gravitational settling should provide insights into how to control it.

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

Results Publications:

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.

Cheng Z, Zhu J, Russel WB, Meyer WV, Chaikin PM. Hard-Sphere Crystallization Kinetics in Microgravity and Normal Gravity. Applied Optics. 2001;40:4146.

Cheng Z, Chaikin PM, Zhu J, Russel WB, Meyer WV. Crystallization Kinetics of Hard Spheres in Microgravity in the Coexistence Regime: Interactions between Growing Crystallites Physical Review Letters. 2001; 88:015501.

de Hoog EHA, Kegel WK, van Blaaderen A, Lekkerkerker HNW. Direct observation of crystallization and aggregation in a phase-separating colloid-polymer suspension. Physical Review. 2001;E.64:021407.

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.

Last Update: 10/10/2008