BCAT-4-Poly
Binodal Colloidal Aggregation Test - 4: Polydispersion

You are currently logged in as jtate.
You will automatically be logged out after 30 minutes of inactivity.

Update This Record | Increments | Investigators

Field Descriptions

Principal Investigator(s):
Paul M. Chaikin, Ph.D., Princeton University, Princeton, NJ and New York University, New York, NY

Contact(s):
Primary - Paul M. Chaikin, (212) 998-7694
Secondary - Andrew D. Hollingsworth, (212) 998-8460
Project Scientist - William Meyer, (216) 433-5011

Mailing Address(es):
Dr. Paul M. Chaikin
4 Washington Place
Mail Box 014
New York University
New York, NY 10003

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

Sponsoring Agency: National Aeronautics and Space Administration (NASA)

Increment(s) Assigned: 17, 18, 19, 20

Brief Research Summary (PAO): Binodal Colloidal Aggregation Test - 4: Polydispersion (BCAT-4-Poly) will use model hard-spheres to explore seeded colloidal crystal nucleation and the effects of polydispersity, providing insight into how nature brings order out of disorder. Crewmembers photograph samples of polymer and colloidal particles (tiny nanoscale spheres suspended in liquid) that model liquid/gas phase changes. Results will help scientists develop fundamental physics concepts previously cloaked by the effects of gravity.

Research Summary:

- Binodal Colloidal Aggregation Test - 4: Polydispersion (BCAT-4-Poly) is one of four investigations in the Binary Colloidal Alloy Test suite of experiments. BCAT-3: Binary Alloy (BCAT-3-BA), BCAT-3-4: Critical Point (BCAT-3-4-CP) and BCAT-3: Surface Crystallization (BCAT-3-SC) were performed on previous ISS expeditions.

- BCAT-4-Poly consists of polydisperse colloidal particles which push the boundaries of known self-assembly and thermodynamics processes in complex fluids. The effects of polydispersity on crystallization in the glassy volume fraction range will be studied.

- Three contrasting samples will be examined. Clean observations of phase transitions in these systems of particles provide much needed insight about the interplay of particle interactions, polydispersity and sedimentation in affecting phase behavior. Traditional questions about the relative packing fractions, which crystallization phase is manifested, and the passing from one phase to the other, may be studied in these systems without the perturbing effects of sedimentation and gravitational jamming.

Exploration Talking Points: STS-123/1J/A carries new experiments and facilities to ISS

Detailed Research Description: The Binodal Colloidal Aggregation Test (BCAT) hardware supports four experiments. The first hardware, Binary Colloidal Alloy Test - 3, consisted of three separate investigations, Binary Alloy (BCAT-3-BA), Critical Point (BCAT-3-4-CP) and Surface Crystallization (BCAT-3-SC), which were delivered to the International Space Station (ISS) during expedition 8. The next hardware, BCAT-4, consists of two separate investigations, Critical Point (a continuation of the investigation on BCAT-3) and Polydispersion (BCAT-4-Poly).

The BCAT-4-Poly polydispersed (characterizing the variation in particle size in the dispersed phase) and seeded samples will consist of polymethyl methacrylate (PMMA) particles in an index matching decalin/tetralin mixture (the same colloid and solvent materials as the critical-point samples, but at a volume fraction of ~0.59). Although these samples are at or above the so-called glass transition point, colloidal crystals are expected to form. The particle size distribution and the addition of spherical seed particles should affect the free energy barrier for crystal nucleation, that is, the rate at which crystals nucleate. Photography will be used to study their evolution, with the hope of seeing white light backlit samples diffract the light so that the color changes with viewing angle. This will help reveal the shape of the nuclei, which provide information about the way the crystals grow in microgravity. The crystallites might grow fast in certain crystallographic directions which could give them a layer like structure. Also their shape will give some hints about the processes that limit the growth. Comparison with analogous ground-based experiments will reveal differences in the growth behavior in microgravity.

Project Type: Payload

BCAT-4 Slow Growth Sample Module.
(click to enlarge)

Cathy Frey (BCAT Crew Trainer) and Peter Lu (BCAT Investigator) showing astronaut Daniel Tani, time-lapse video of sample evolution from photos taken by Bill McArthur during ISS Expedition. 12.
(click to enlarge)

Operations Location: ISS Inflight

Brief Research Operations:

- BCAT-4 consists of ten different individual sample cells. BCAT-4-Poly uses three of the sample cells.
- Crew members will homogenize the samples and will look for crystals at various lighting angles. The crystals will be manually photographed and downlinked for immediate feedback to the crewmembers.
- After photography the samples are stowed and left undisturbed to allow for continued growth of the colloidal structure for up to 6 months.

Operational Requirements: The BCAT-4 hardware consists of ten samples of colloidal particles. The microscopic colloid particles and a polymer (samples 8 - 10) are all mixed together in a liquid. The BCAT-4 samples are contained within a small case the size of a school textbook. The experiment requires a crew member to set up on the Maintenance Work Area (MWA) or on a handrail/seat track configuration, EarthKAM hardware and software to take digital photographs of samples 8 - 10 at close range using the onboard Kodak 760 camera. The pictures are then downlinked to investigators on the ground for analysis.

Operational Protocols: A crewmember sets up all hardware on the Maintenance Work Area (MWA). The crewmember then homogenizes (mixes) the sample(s) and takes the first photographs, manually. The crewmember activates the EarthKAM software to automate the rest of the photography sessions over a 3-day to 3-week period. Crewmembers perform a daily status check to assure proper alignment and focus of the camera. At the completion of the session, a crewmember tears down and stows all hardware.

Review Cycle Status: PI Reviewed

Category: Physical Sciences in Microgravity

Sub-Category: Materials Science

Space Applications: BCAT-4-Poly 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: Generally, colloidal nucleation experiments seek an understanding of the most fundamental liquid/solid transition. Though direct applications of that understanding do not drive the research, growth of ordered colloidal phases has attracted interest in a number of areas, *e.g.* ceramics, composites, optical filters and photonic bandgap materials. Moreover, there is currently great interest in using fields and gradients to control order in self-assembled systems such as diblock copolymers and microemulsions for advanced materials.

Manifest Status: Completed

Supporting Organization: Exploration Systems Mission Directorate (ESMD)

Previous Missions: The predecessors to BCAT-4; BCAT-3 operated on ISS, and BCAT, operated on Mir in 1997 and 1998.

Results Status:

Results Review Status:

Related Publications:

Man WN, Donev A, Stillinger FH, Sullivan MT, Russel WB, Heeger D, Inati S, Torquato S, Chaikin PM. Experiments on random packings of ellipsoids. Physical Review Letters. 2005 ;94: 198001.

Donev A, Stillinger FH, Chaikin PM, Torquato S. Unusually dense crystal packings of ellipsoids. Physical Review Letters. 2004 ;92: 255506-1.

Donev A, Cisse I, Sachs D, Variano EA, Stillinger FH, Connelly R, Torquato S, Chaikin PM. Improving the density of jammed disordered packings using ellipsoids. Science. 2004 ;303: 990.

Cheng Z, Zhu J, Chaikin PM, Phan SE, Russel WB. Nature of the divergence in low shear viscosity of colloidal hard-sphere dispersions. Physical Review Letters E. 2002 ;65(4): 041405(8).

Cheng ZD, Chaikin PM, Zhu JX, Russel WB, Meyer WV. Crystallization Kinetics of Hard Spheres in Microgravity in the Coexistence Regime: Interactions between Growing Crystallites. Physical Review Letters. 2002 ;88: 015501.

Cheng ZD , Zhu JX, Russel WB, Meyer WV, Chaikin PM. Colloidal hard-sphere crystallization kinetics in microgravity and normal gravity. Applied Optics. 2001 ; 40: 4146-4151.

One Year Post Flight Report(s):

Web Sites:
BCAT-3
Photographing Physics: Critical Research in Space
Experimental Soft Condensed Matter Group

One-pager: BCAT-4-Poly

Related Payload(s): BCAT Investigations, EXPPCS

Comments: 6/19/2007: Updated the Space Applications, defined polydispersion and PMMA per email received from the PI. jmt

1/28/08: Updated the title to reflect the RFMI input.jmt

Last Update: 09/23/2008