

Colloidal Gelation-2 and Colloidal Disorder-Order Transition-2 Investigations Conducted on STS-95

The Colloidal Gelation-2 (CGEL-2) and Colloidal Disorder-Order Transition-2 (CDOT-2) investigations flew on Space Shuttle Discovery mission STS-95 (also known as the John Glenn Mission). These investigations were part of a series of colloid experiments designed to help scientists answer fundamental science questions and reduce the trial and error involved in developing new and better materials. Industries dealing with semiconductors, electro-optics, ceramics, and composites are just a few that may benefit from this knowledge.

The goal of the CGEL-2 investigation was to study the fundamental properties of colloids to help scientists better understand their nature and make them more useful for technology. Colloids consist of very small (submicron) particles suspended in a fluid. They play a critical role in the technology of this country, finding uses in materials ranging from paints and coatings to drugs, cosmetics, food, and drink. Although these products are routinely produced and used, there are still many aspects of their behavior about which scientists know little. Understanding their structures may allow scientists to manipulate the physical properties of colloids (a process called "colloidal engineering") to produce new materials and products. Colloid research may even improve the processing of known products to enhance their desirable properties.

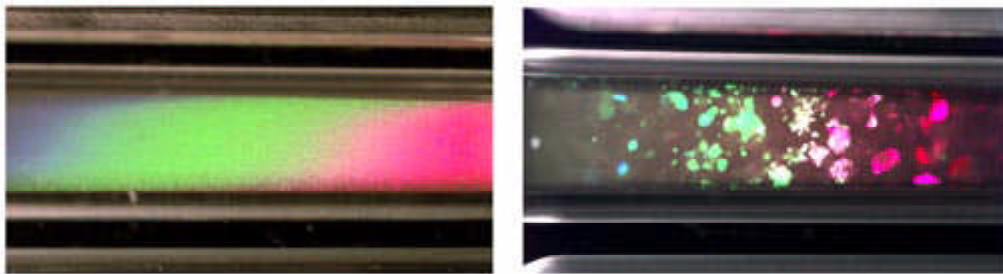
The CGEL-2 investigation was designed to advance colloid research through the study of three kinds of colloid systems:

1. Binary colloidal alloys, which are suspensions of particles of two different sizes
2. Colloid polymer solutions, which form gels or glasslike materials
3. Fractal colloid aggregates, which are colloids that have repeating structural patterns and networks



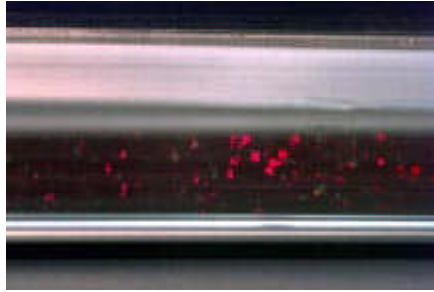
Astronauts Chiaki Mukai and Pedro Duque prepare to take photographs of the colloidal crystals on top of the glovebox during STS-95 ground training.

The STS-95 CGEL-2 investigation revealed that the gels formed from the colloid polymer solutions, which tend to last only a few minutes on Earth, are stable over long periods of time in microgravity. The delicate fractal colloid aggregates grow much larger without the destructive pull of gravity. The binary colloidal alloy samples studied exhibited similar growth rates on Earth and in space. The STS-95 studies brought invaluable new information that can be applied to future colloidal materials synthesis.



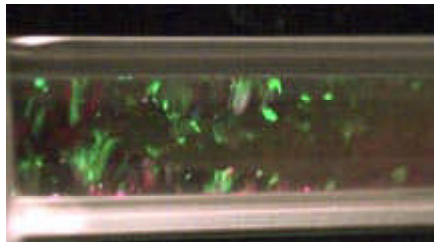
These CGEL-2 samples taken during STS-95 show binary colloidal suspensions that have formed ordered crystalline structures in microgravity. Left: There are more particles; therefore, many, many crystallites (small crystals) form. Right: There are fewer particles; therefore, the particles are far apart, and fewer, much larger crystallites form.

The CDOT-2 investigation also focused on the study of colloidal systems, but for different reasons. CDOT-2 used colloidal suspensions of microscopic solid plastic spheres as a model of atomic interactions. A colloidal suspension containing particles of very uniformly sized spheres that cannot penetrate each other (hard spheres) shares a fundamental characteristic with atomic systems. Under the proper conditions, both undergo a transition from a disordered liquid state to an ordered solid state, such as when water molecules become ordered to form ice.



The snowflakelike crystallites, or dendrites, clustered in the center of this CDOT-2 sample taken during STS-95 have never been seen in such samples on Earth. Similar structures were seen for the first time in the CDOT experiment on STS-73. This experiment showed that dendritic growth occurs in samples with even more particles (i.e., higher volume fractions) than in those that flew on STS-73.

During the STS-95 CDOT-2 investigation, dendrites were observed for a sample with a volume fraction (volume of particles per container volume) between 0.494 and 0.545. On Earth, these butterflylike structures settle to the bottom of the container and the "wings" shear off. The observation of these dendrites reveals important information about the nucleation and growth of crystals.



This CDOT-2 sample, which flew on STS-95, contains so many colloidal particles that it behaves like a glass. In the laboratory on Earth, the sample remained in an amorphous state, showing no sign of crystal growth. In microgravity, the sample crystallized in 3 days, as did the other glassy colloidal samples examined during the CDOT-2 experiment.

The STS-95 CDOT-2 investigation also revealed that crystallization can occur in samples that have a volume fraction larger than the formerly reported glass transition of 0.58. This has great implications for theories of the structural glass transition. These glassy samples never crystallized on Earth, but once grown in space, the crystals were strong enough to survive shuttle reentry and landing.



CGEL-2/CDOT-2 experiment hardware that flew on STS-95.

The CGEL-2/CDOT-2 investigations used the same experiment hardware that had been used on Earth to observe colloidal systems in orbit around the Earth, where the force of gravity is about a million times less than at the Earth's surface (microgravity). In this reduced-gravity environment, astronauts were able to test current theories that model atomic interactions as hard sphere systems and to study the properties of colloidal structures without the problems of sedimentation and convection obscuring the true nature of the colloidal system.

Professors Paul M. Chaikin and William B. Russel of Princeton University are the principle investigators for the CDOT-2 investigation, and Professors David A. Weitz from the University of Pennsylvania and Peter N. Pusey from the University of Edinburgh, Scotland, are the principal investigators for CGEL-2. The experiment hardware was designed, built, and tested at the NASA Glenn Research Center at Lewis Field with participation from Aerospace Design and Fabrication, Inc., the National Center for Microgravity Research, NYMA, Inc., the Ohio Aerospace Institute, and Princeton University.

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