Zeolite Crystal Growth

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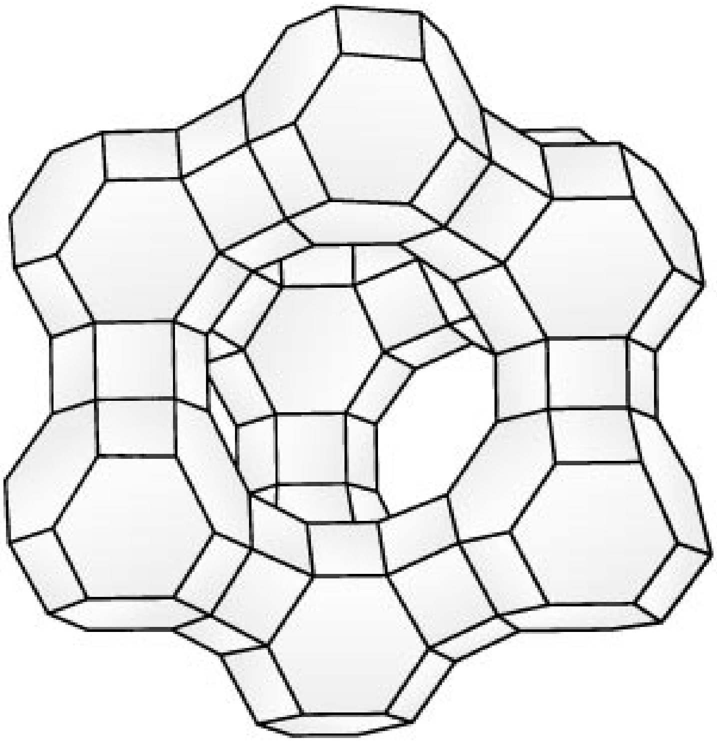
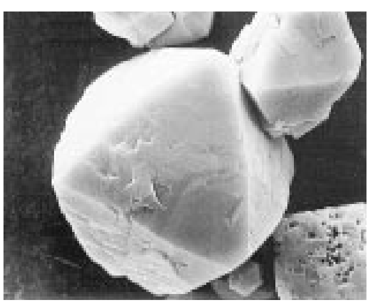
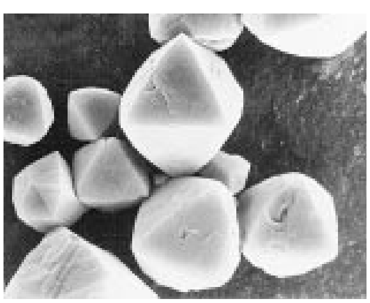


Drawing of a Typical Zeolite Crystal





Experimentation on USML-1 produced larger and better crystals (top) than can be obtained in similar ground-based processing (bottom).

Purpose: To establish a level of understanding of zeolite crystallization and growth so as to achieve high yields of large, nearly perfect crystals in space

Significance: Zeolite crystals are used in the chemical process industry as filters, catalysts for reactions, and adsorbents. Their three-dimensional crystal structures are capable of selective filtration (*adsorption*), so zeolite crystals are often used as sieves to filter molecular compounds selectively. These crystals also have potential applications as nuclear waste scavengers and are useful as quantum confinement hosts for semiconductor materials.

To improve existing catalytic and adsorbent processes, however, scientists need a better understanding of the structure of zeolite. Theoretically, large zeolite crystals, 500 to 1000 times the size of crystals grown on Earth, can be grown in microgravity. Analysis of the crystalline structure of space-grown zeolites may help to optimize their use as catalysts and adsorbents. Additionally, nearly perfect crystalline structures could be used as industrial membranes, which could result in major advantages over current separation and catalytic processes, or as hosts for semiconductor material to create electronic and optical properties specific to the form of "quantum dots."

The Zeolite Crystal Growth Furnace flew on the First United States Microgravity Laboratory in the space of two middeck lockers and in Spacehab 1. Companion experiments in the Glovebox helped maximize the science return, leading to new strategies and methodologies for improving zeolite crystal growth in orbit.

Evaluation of the zeolite crystals grown on the First United States Microgravity Laboratory and Spacehab 1 indicate that most samples where nucleation was controlled experienced enhanced growth and achieved a degree of crystal perfection as high or higher than any crystal produced on Earth. Several crystals of zeolite A appeared to be approaching the theoretically perfect silicon/aluminum ratio — the first time such a ratio has ever been achieved. Area increases of 96 percent and volume increases of 175 percent beyond the Earth-grown control samples were observed for zeolite A. Area and volume increases for crystals of zeolite X increased 50 percent and 83 percent, respectively, when compared to the best laboratory samples ever produced by the Principal Investigator.

On this mission, the Zeolite Crystal Growth experiment will continue to investigate techniques for synthesizing large zeolite crystals in microgravity and will evaluate new mixtures of zeolite materials.

Method: The experiment consists of 38 autoclaves that will be activated and loaded into a furnace. The autoclaves contain two source solutions, one aluminum-based and the other silicon-based, and are designed to be loaded on Earth and mixed in orbit. Activation occurs when a nut is turned to mix the two solutions. The amount of mixing for different autoclaves and mixtures is determined by additional experiments in the Glovebox that use clear autoclaves.