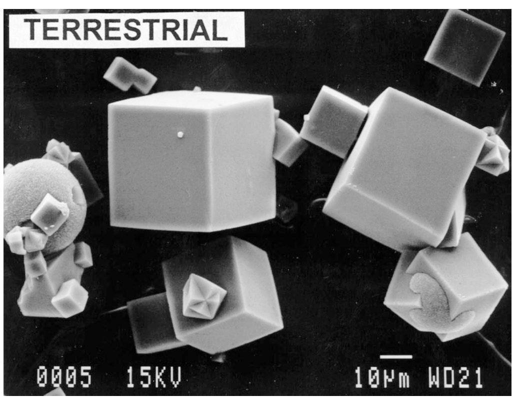
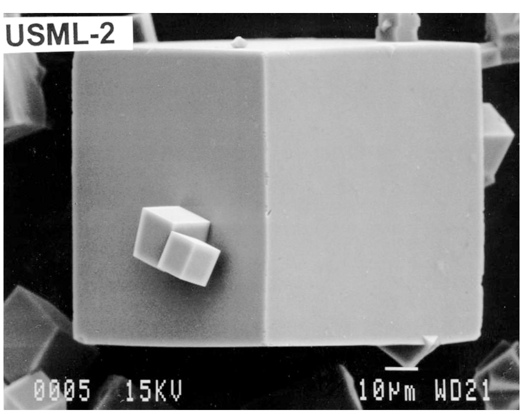
# It's a Filter, It's a Sponge

## Zeolite Crystal Growth

What is as hard as a rock but works like a sponge? This isn't a difficult riddle — such substances, called "zeolites," are actually found throughout nature. Zeolites have a rigid crystalline structure with a network of interconnected tunnels and cages, similar to honeycomb. But while a sponge needs to be squeezed in order to release water, zeolites only give up their contents when they are heated to expand. The name "zeolite" comes from the Greek words zeo (to boil) and lithos (stone), literally meaning "the rock that boils."

There are nearly 50 different types of naturally-occurring zeolites, and they vary in crystal structure, molecular pore size, and chemical composition, among other aspects. Variations can also occur between zeolites of the same group, due to the different environmental conditions where a zeolite may be found. Impurities in the environment, for instance, can affect how a zeolite forms.



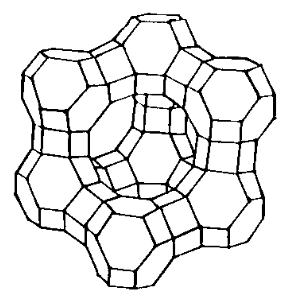




Zeolite crystals (top) grown in a ground control experiment. Zeolite crystals (bottom) grown in microgravity by Dr. Sacco on the USML–2 mission.

**Commercial Space Center:** Center for Advanced Microgravity Materials Processing at Northeastern University, Boston, MA
**Director:** Al Sacco

The Center for Advanced Microgravity Materials Processing (CAMMP), a NASA-sponsored Commercial Space Center, is working to improve zeolite materials for storing hydrogen fuel. CAMMP is also applying zeolites to detergents, optical cables, gas and vapor detection for environmental monitoring and control, and chemical production techniques that significantly reduce by-products that are hazardous to the environment.

Zeolites could help us move from an economy that relies on petroleum to one that uses hydrogen for its fuel. Hydrogen would be an infinitely renewable, pollution-free fuel: hydrogen is the most abundant element in the universe, and the main product of hydrogen combustion is $H_2O$ (water). One of the major problems remaining to be solved is the efficient storage of hydrogen, but zeolite and zeo-type materials are being tested as a possible storage medium.



Zeolite crystals form in a number of complex geometric shapes which make them highly absorbent.

According to Dr. Albert Sacco, Jr., Director of CAMMP, zeolites are a $ 2 billion-a-year market. Since chemical processing is a trillion-dollar industry worldwide, any improvement in the understanding of zeolite materials could have an enormous economic impact. More importantly, zeolites could be used in even more ways to make industry safer and less damaging to the environment. Thanks to research in space, CAMMP may someday make zeolites more useful than ever before.

## Background Information

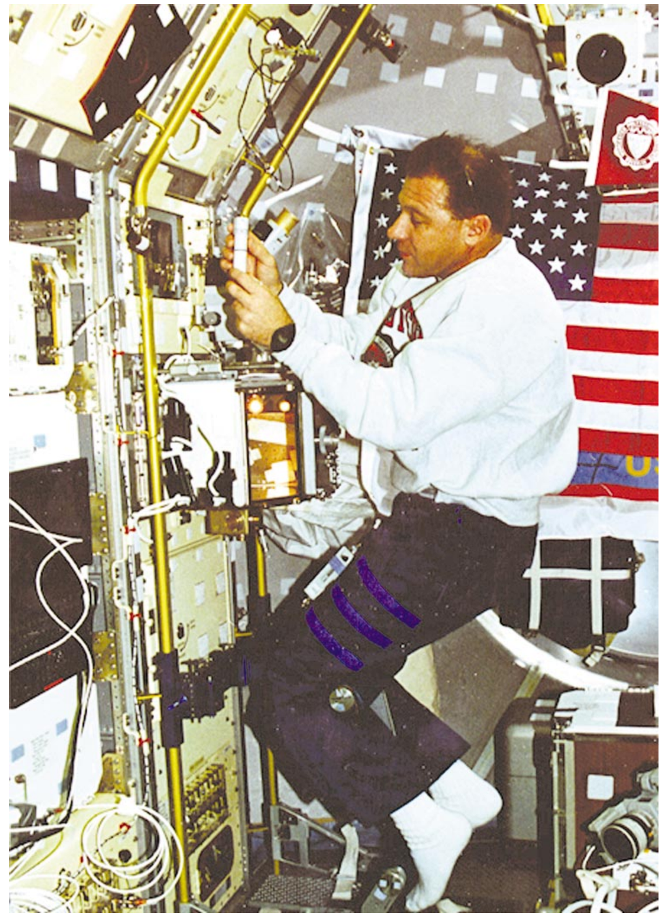
### Science

A large part of CAMMP's research depends on figuring out the molecular structure of zeolites. Due to the extremely small size of these molecules (2 to 8 microns), it is difficult to get accurate structural information about zeolites. Such information can be readily achieved, however, if zeolite crystals can be grown 200 to 1,000 times their normal size. CAMMP has discovered that it is possible to grow such large crystals in the microgravity conditions on the Space Shuttle.

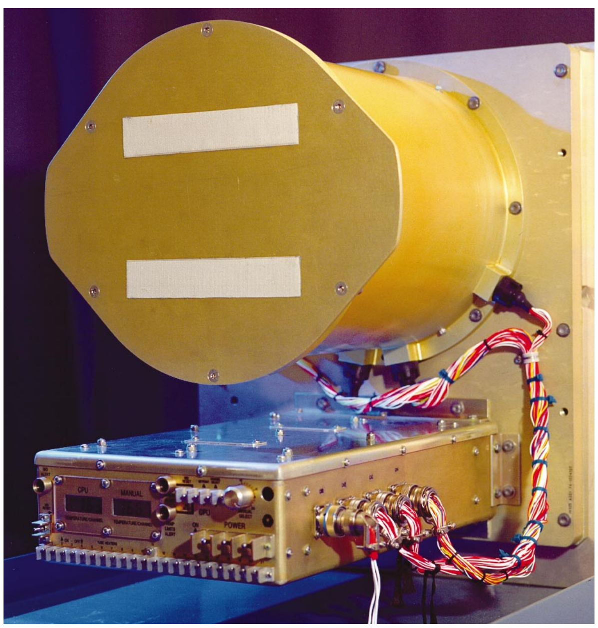
Research on STS–107 is an important part of this process. Commercial investigations will make use of new and improved Zeolite Crystal Growth (ZCG) hardware that has been developed for use on the International Space Station. The hardware consists of sample tubes that hold the components that form zeolites, and a furnace unit used to process the samples.

Operations will begin with the crew using a cordless screwdriver to mix the component elements in the sample tubes together. The mixing protocol will vary with each sample, so that researchers can gain a better understanding of the nucleation process and how to control it. Once mixing is complete, the samples will then be placed in the furnace for automated processing. The samples will be examined after their return to Earth.

When enough is known about these materials to be able to manipulate both the nucleation and growth, CAMMP can custom design them for specific applications. By selectively processing molecules, CAMMP could make chemical processes more energy efficient, and also reduce unwanted chemical by-products. This type of processing ultimately could reduce production costs and pollution. CAMMP plans to target zeolite membranes toward isomerization, dehydrogenation, and desulfurization: reactions that are critical to the world-wide processing of petroleum and petrochemical products. In addition, novel applications are being developed to use zeolite membranes to separate and purify gases and liquids for pollution control.



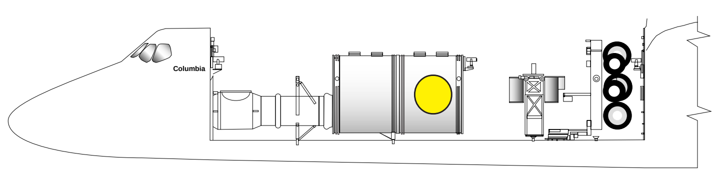
Al Sacco, Payload Specialist and Director of the Center for Advanced Microgravity Materials Processing performs zeolite crystal growth experiments on the USML–2 mission



Pictured above is the existing ZCG hardware on STS–57 (SPACEHAB-01) with the front cover removed.

**Applications**

- The ability of zeolites to adsorb liquids and gases makes them useful in many everyday products such as air-fresheners, kitty litter, and laundry detergents.
- Zeolites are currently used in everything from animal feed supplements to the decontamination of radioactive waste
- Because zeolites have extremely small pores, they can also be used as filters, such as air and water filters that help clean up the environment.
- Zeolites are also used as fillers for composite paper, rubber, plastics, or ceramics, and can be enhanced to become specialty lightweight ceramic and concrete products.




Approximate location of this payload aboard STS–107.