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Apr 27th, 1:00 PM - 4:00 PM

## Paper Session II-A - Biomedical Applications from Microgravity Experiments Flown on the CMIX Commercial Shuttle Flights

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# 31<sup>st</sup> Space Congress

Space Exploration and Utilization  
for the Good of the World

April 26, 27, 28, 29, 1994

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BIOMEDICAL APPLICATIONS FROM MICROGRAVITY EXPERIMENTS  
FLOWN ON THE CMIX COMMERCIAL SHUTTLE FLIGHTS  
(AN ILLUSTRATION FOR POTENTIAL BENEFITS TO THE NATION)

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BIOMEDICAL APPLICATIONS FROM MICROGRAVITY EXPERIMENTS FLOWN ON  
THE CMIX COMMERCIAL SHUTTLE FLIGHTS  
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John M. Cassanto  
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Dr. Paul Todd  
Dr. Richard Korszun

NASA's initiatives to encourage the US private sector to invest in space hardware, products, and services are approximately 10 years old. These initiatives have worked and have encouraged the private sector to invest in commercial space projects. The Office of Advanced Concepts and Technology (formally NASA's Office of Commercial Programs) has over the years initiated several innovative programs to provide access to space for commercial entities having developed their own hardware with private sector resources. These innovative agreements range from direct "pay to fly" agreements to barter arrangements with a commercial entity.

The purpose of this paper is to present an overview of the Commercial MDA ITA Experiments (CMIX) Program, which has flown two Space Shuttle missions during the past 16 months. The paper will show typical data results of new biomedical applications that can be obtained from space processing operations that can be a benefit to the US.

Figure 1 presents a comparison of microencapsulation of drug experiments conducted in space and on Earth. The unique space microcapsules clearly show an advantage because the microspheres are more uniform in size and sphericity, and have multilayers of alternating aqueous and non-aqueous fluids. They also have a tougher skin that allows manipulation and a long shelf life. Microcapsule of anti-tumor drugs, antibiotics, and enzymes that dissolve blood clots have been processed in space. Microencapsulation technology is used for drug delivery systems.

Figure 2 shows an aldolase protein crystal grown in space, which is significantly larger than the same protein crystal grown on Earth. Data from several flights suggest that the rate of growth of some protein crystals can be accelerated in space.

This is particularly important to ITA's space cancer research program. Figure 3 shows a small 50 micron urokinase protein crystal grown in space on our commercial CMIX-2 Shuttle flight in April 1993. Urokinase is an enzyme that is secreted when cancer metastasis occurs. Accordingly, if large enough protein crystals of urokinase can be grown to permit the structure to be determined, a drug could be designed to inhibit the spread of certain cancers, especially breast cancer. Urokinase protein crystals have been grown in eight days using ITA's commercial automated laboratory on three separate Shuttle flights using two different techniques. The 50 micron urokinase protein crystal grown in space is too small to determine the structure, but appears to be repeatable for the flights. It takes approximately six months or more to grow the same size crystal on the ground. The structure of urokinase is not known due to the inability to grow the crystal large enough on the ground. Our space microgravity research leads us to believe that the accelerated growth rate in space will produce larger crystals which are also better ordered and which will produce a better diffraction pattern.

Efforts are being made to grow large urokinase protein crystals for structural determination on the CMIX-3 flight scheduled for 1994. This cancer research is being sponsored and funded by ITA with the support from other organizations. We will be flying both a longer mission and will be trying a third crystal growth technique that promises to produce sufficiently larger crystals.

The paper will also illustrate how biomedical applications from space processing can potentially benefit the nation.

ITA

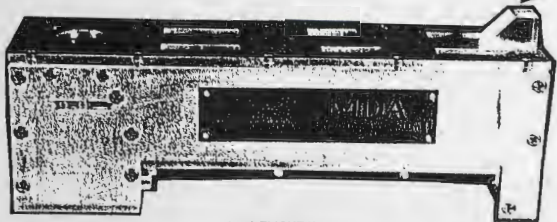
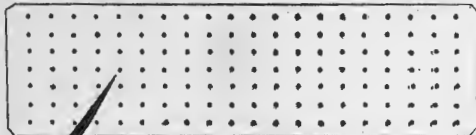
INSTRUMENTATION  
TECHNOLOGY  
ASSOCIATES, INC.

# The Materials Dispersion Apparatus (MDA) Minilab is Capable of Processing up to 140 Experiments in Space

SPECIMEN BLOCK CONTAINING 140 TEST SAMPLE WELLS



PROTEIN CRYSTAL GROWN IN THE MDA

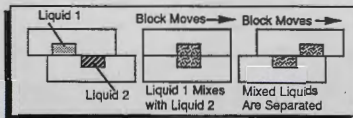
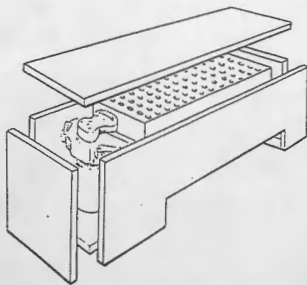


MDA FLIGHT UNIT

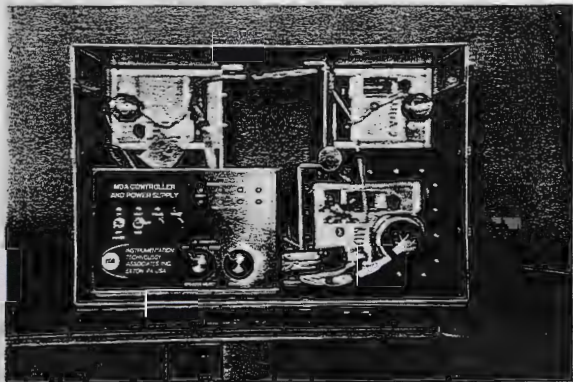
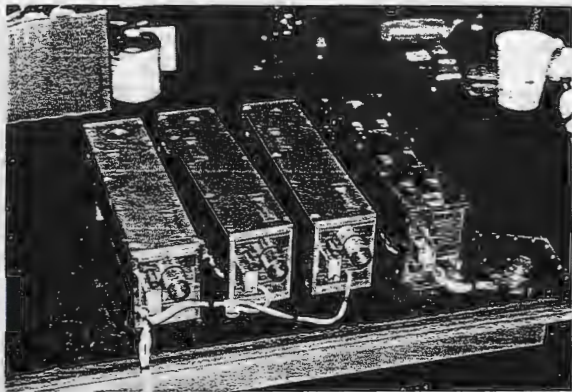
## APPLICATIONS :

- BIOMEDICAL (protein crystal growth)
- FLUID SCIENCES (diffusion)
- MANUFACTURING (thin film membrane casting)

## MDA Principle of Block Operation



The CMIX-1 & 2 Payloads flown on  
Space Shuttle Flights STS-52 & 56  
Utilized four ITA MDA Minilab Units





## MDA Flight Blocks Being Loaded During the Fluid Loading Rehearsal for STS-37 at KSC, Florida, March 3-8, 1991



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# Astronaut Ken Cockrell Activating the ITA MDA Minilabs of the CMIX-2 Payload on Space Shuttle Flight STS-56

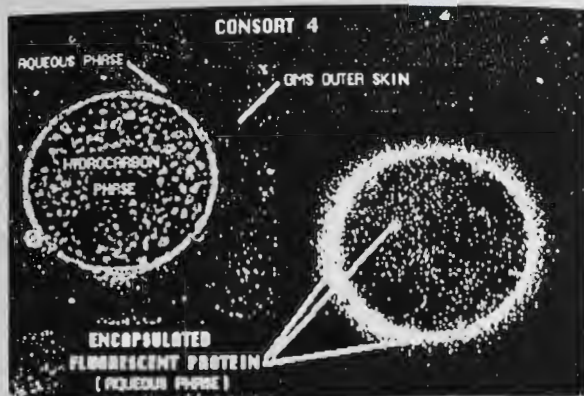
**NASA**National Aeronautics and  
Space Administration

STS056-01-013

Lyndon B. Johnson Space Center  
Houston, Texas 77058



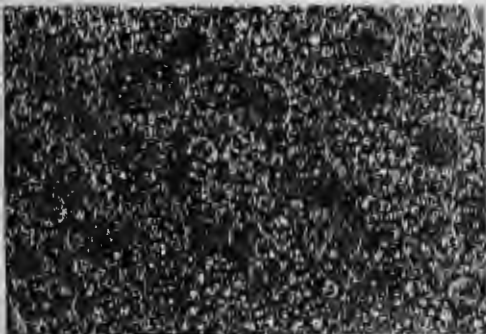
## Microencapsulation Experiment for Drug Delivery



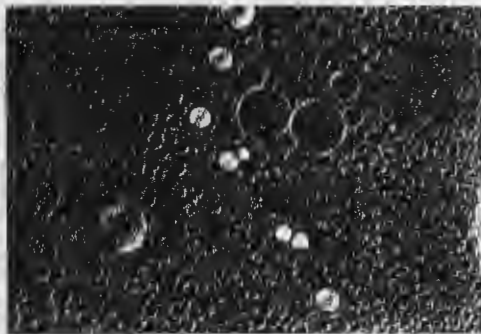
This experiment was conducted by Dr. Dennis Morrison of NASA/JSC and Dr. Ben Mosier of the Institute for Research in Houston, Texas on ITA's MDA minilab flown on the Consort 4 sounding rocket flight.

## Microgravity Encapsulation of Drug Experiments Conducted in Space Show More Uniform Size and Sphericity

### EARTH



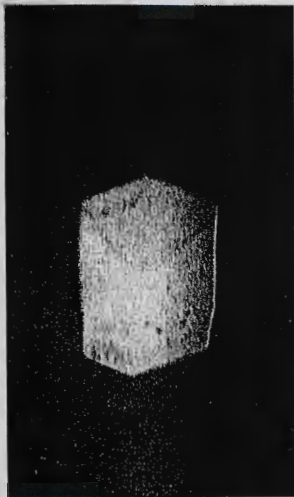
### SPACE



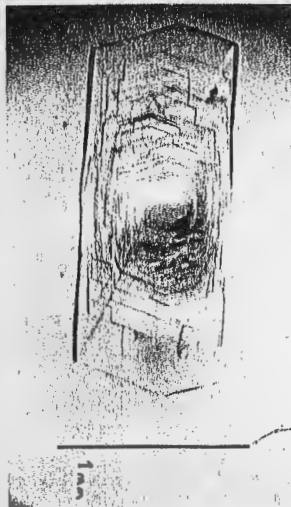
- Earth experiments show random size and single-walled unilamellar microcapsules
- Space experiments show uniform size and sphericity plus unique multi-lamellar microspheres
- Space data obtained in ITA's automated laboratory flown on Shuttle flight STS-56 on the CMIX-2 payload
- Photos courtesy of Dr. Dennis Morrison and Dr. Benjamin Mosier

# Aldolase Protein Crystals Grown in ITA's Automated Laboratory Show that the Space Grown Crystals Tend to be Larger

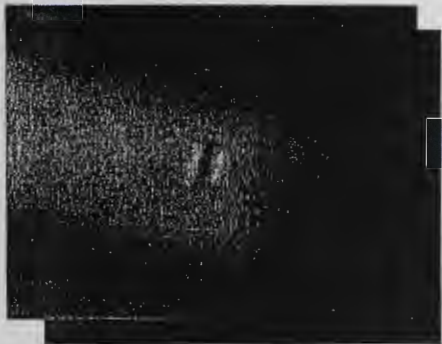
**EARTH**



**SPACE**



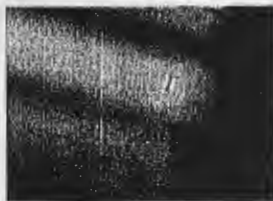
## Urokinase Protein Crystal Growth in Microgravity A Case Study in Cancer Remediation



Blow-up of Urokinase Protein Crystal  
(50 micron crystal)



- On Earth this protein crystal requires 6 or more months to grow
- In Space this protein crystal was grown in ITA's Automated Laboratory in 8 days
- Increased growth rate in Space (size) permits structure determination
- Structure determination permits rational drug design



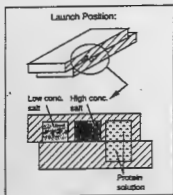
Urokinase Protein Crystal  
(50 micron crystal)



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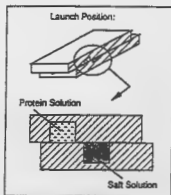
# MDA MINILAB DATA SHOWS THE GRADIENT DIFFUSION TECHNIQUE PRODUCES LARGER PROTEIN CRYSTALS

## STEP GRADIENT DIFFUSION



## TECHNIQUE

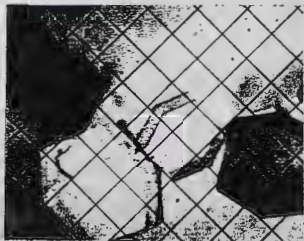
## LIQUID-LIQUID DIFFUSION (DOUBLE DIFFUSION)



ALDOLASE



LYSOZYME



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FLIGHT OPPORTUNITIESPresent  
March 94