



Chemistry in Space

a very brief survey

Brad Carpenter
Program Scientist
Biological and Physical Sciences Division



Chemistry in the (Human) Space Program

- Space Exploration
 - Life Support
 - In-situ Resources for Propulsion (Oxygen production)
- Space Industry/Manufacturing
 - Biotechnology
 - Electronic Materials
 - Metals & Glasses
 - Others
- Scientific Research
 - Soft/Active Matter
 - Thermophysical Properties in Materials Science
 - Building a Foundation for the Future of Space Development

Chemistry in Exploration Missions

- Launch mass is a key parameter for long-duration exploration missions
- Mass requirements can be reduced by recycling consumables (O_2 , H_2O), or by producing high-mass requirements (O_2 for propulsion) from local materials
- ISS O_2 recycling
- ISS Water recovery
- Lunar O_2 production
- Mars O_2 production



Chemistry in Commercial Development

Commercial/economic development long recognized as a long-term objective

- Von Braun initiates Materials Processing in Space, early 1970's
- NASA Office of Commercial Programs, 1980's - ~2000
- International Space Station
- The next generation

“IN THE ZERO-GRAVITY OF SPACE, WE COULD MANUFACTURE IN 30 DAYS LIFESAVING MEDICINES IT WOULD TAKE 30 YEARS TO MAKE ON EARTH. WE CAN MAKE CRYSTALS OF EXCEPTIONAL PURITY TO PRODUCE SUPER COMPUTERS, CREATING JOBS, TECHNOLOGIES AND MEDICAL BREAKTHROUGHS BEYOND ANYTHING WE EVER DREAMED POSSIBLE.”

RONALD REAGAN

STATE OF THE UNION - 1985



Chemistry in Commercial Development

Biotechnology

Bioseparations (electrophoresis, phase partitioning)

Lyophilization

Protein Crystal Growth

Protein Crystallization

Cell Fusion

Three-Dimensional Tissue Culture

In Vivo, In Vitro Drug Development Testing Models (Bone Loss, Muscle Loss)

Chemistry in Commercial Development

Materials Science/Engineering/Processing

Semiconductor crystal growth from melt

Semiconductor crystal growth from vapor

Unique structures in solidified alloys

Large zeolite crystals

Organic crystals from solution (e.g. triglycine sulfates)

Vapor transport of organic solids

Manufacturing in Space (semiconductor devices, glass fibers, additive manufacturing)

Chemistry in Scientific Research

Combustion reaction kinetics

Thermophysical properties of reactive molten solids

Dynamic behavior of colloids and functional materials

Phase transitions

Glass formation

Chemical self-organization

Process research supporting transport of Earth-based technologies to new destinations - unit operations for new environments

... Future NASA directions will be guided by the Decadal Survey expected to be delivered this Summer [Decadal Survey on Biological and Physical Sciences Research in Space 2023-2032](#)

Follow-up

Please feel free to contact me for further discussion about any of the topics I've mentioned today

bcarpenter@nasa.gov

I'm not an expert in most of the material presented, but I can help you find information