

# EXPLORATION

## PROCESSING AND SYNTHESIS OF MATERIALS

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### Rationale

The processing and synthesis of materials will play an increasingly important role in the exploration of space. Specifically, the conservation and re-use of materials will be essential and hence will provide unique challenges.

### Opportunity

The deep exploration of space will require a philosophy of self-sustainable materials processing. This will be true in both microgravity conditions such as the Space Station and in the presence of significant gravitational forces, such as on Mars. This underlying philosophy would be part of an “ecosystem” approach to the conservation of materials in regard to the fabrication of components for a wide range of needs (for example, structures, fuels, foods, and drugs). Many of these approaches will be bio-inspired and/or bio-derived.

For over 20 years, the preferred materials processing technique in space has been acknowledged to be, of necessity, powder-based. Conventional casting and molding operations would not be practical for a number of reasons. In spite of the need to avoid particulate contamination and dispersal, powder processing could allow maximum compactness of the processing operation and minimum energy requirements. The fabrication of structural components would have the additional constraint of generally low-Z materials for consideration of both fuel consumption and minimal secondary radiation production.

Materials would play a central role in various fuel systems. Solar and nuclear power would be the most likely sources for extended travel, e.g., a 1000 day mission. Self-sustaining requirements would provide a primary constraint in addition to well established technologies. Nuclear power would require unique advantages relative to solar for obvious political reasons. If nuclear power was justified, materials selection would be critically important, e.g., a sufficient half-life for the nuclear material and adequate shielding by the containment and structural materials.

Although solar and nuclear power are the obvious candidates for extended travel, materials contributions to alternate fuel systems should also be considered at least for certain specialized applications. Thermoelectric power generation can take advantage of

substantial temperature gradients produced in deep space. The conversion of biomass for energy production might also be appropriate under certain conditions.

While traditional food production has been considered relative to the constraints of an extended habitation such as a Moonbase, synthetic food production might be necessary on extended missions. Such efforts would be bio-inspired and/or bio-derived.

The limited amount of payload on a given mission would also require that materials applications involve multi-functional approaches. An example would be zeolites, silicates with high internal surface areas. These could be used as molecular sieves for gas separation and purification, as well as scaffolds for both catalysis, photosynthesis, and drug delivery.

Crew health presents special challenges in a mission as long as 1000 days. Payload constraints would require that the drug inventory be both optimized and minimized. One approach would be to synthesize an appropriately wide range of drugs from a limited set of biochemicals. The “starting materials” could be either synthetic or natural.