Thermo-Photo-Catalysis of Water for Crewed Mars Transit

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NIAC NASA Innovative Advanced Concepts

Innovation

Smaller, Lighter, Simpler, Efficient OGA Alternative

- **Replace bulky, energy intensive ISS-OGA**
- **Enable passive onboard O_2 (and H_2) production**
- **Use humid air and e^- from light/PV**
- **Microgravity compatible**
- **Vapor feed avoids 2-phase fluid management, improves reliability**

Example Transit Habitat Concept, ESDMD-001, p. 93

Mission

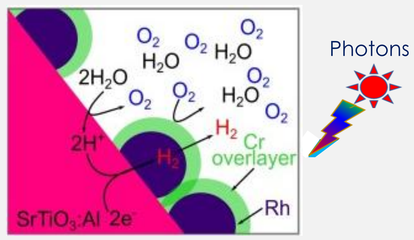
Designed for 2039 long stay Mars transit

- **To support 6 crew, 1,200-day mission**
- **0.89 kg O_2/day-crewmember**
- **Aligns with M2M Reference Mission 1**
- **Modular and scalable for habitat use**
- **Interfaces with Sabatier CO_2 reduction**

Approach

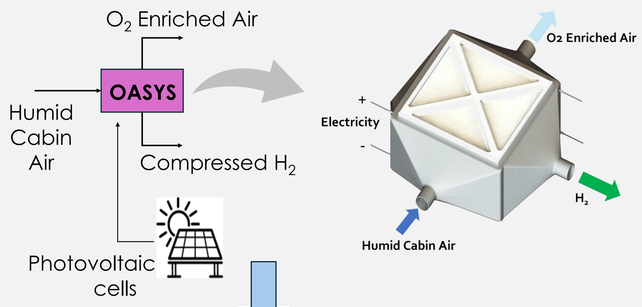
Advanced OGA (heritage water electrolysis technology)
(https://techport.nasa.gov/projects/157887)

Direct Photocatalytic Water Splitting



(*Shearer, et. al. 2020*)

Oxygen Augmentation SYStem (OASYS)

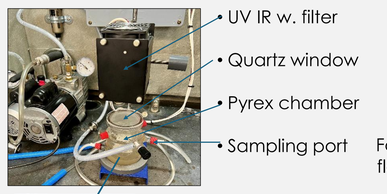


Direct Photocatalysis

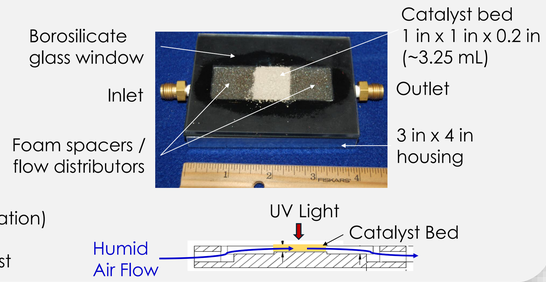
Critical factors:

- **Band gap and surface properties**
- **Charge separation**
- **Integration of co-catalyst**
- **High surface area support**

Test Fixture (batch process)



Test Fixture (flow through)



Photocatalysis Performance

Parameter	Value
Irradiance	1.2 – 6.1 W/cm²
Peak O_2 Production	780 g/m²/h
Avg. O_2 Production	516 g/m²/h
Max. Expt. Efficiency	8.0%
Avg. Expt. Efficiency	3.5 – 5.9%
Avg. O_2 Purity	33% (1:2 O_2:H_2 ratio)
Catalyst Area Required per Crewmember	719 cm²

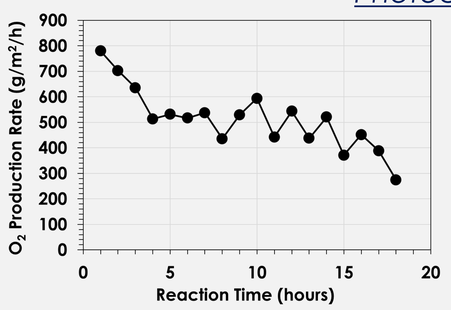
Photocatalysis Challenges

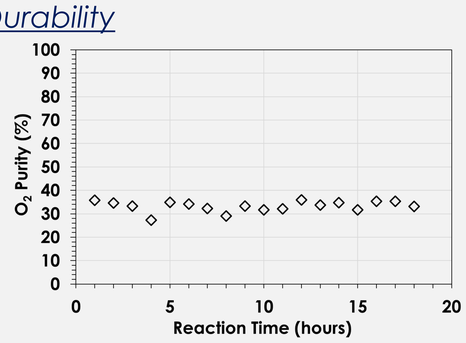
Low O_2 generation rates, Durability, O_2/H_2 separation

Efficiency Losses:

- **Overpotentials (for OER and HER)**
- **Charge carrier recombination**
- **Sub-bandgap photon losses**
- **Limited absorption spectrum**
- **Photocatalyst inefficiencies**

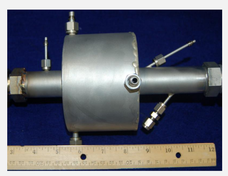
Photocatalyst Durability

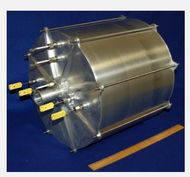




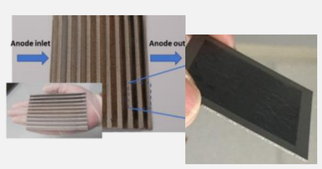
Other PCI Space Technologies from NASA Programs


HTCO/Catalytic Oxidizer


Sabatier


Sorbent


TCC



SOEC/SOFC

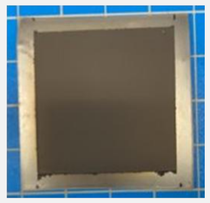
Oxygen Augmentation SYStem (OASYS)

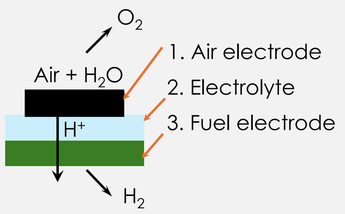
- **Advanced electrochemical cell with novel proton conducting materials**
- **Enables O_2 generation from humid air and simultaneous H_2 separation**
- **System design uses sunlight or other scavenged energy sources**
- **~30% lower energy consumption compared to OGA**

Validating proof of concept to reduce risks

Electrochemical Cell

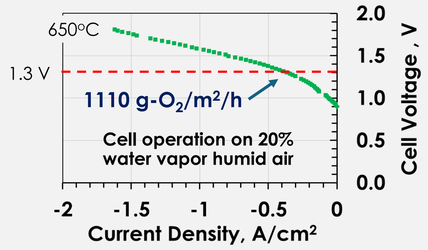
OASYS Proton Conducting Single Cell





Cell, materials & performance validation ongoing

Preliminary Proof-of-Concept



Preliminary data indicates significantly higher O_2 enrichment vs. photocatalysis

OASYS Next Steps

- **Reduce ASR (improve efficiency)**
- **Optimize operating conditions**
- **Address system integration challenges**

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