Active Project (2015 - 2016)

Visible-Light-Responsive Catalyst Development for Volatile Organic Carbon Remediation Project

Center Innovation Fund: KSC CIF Program | Space Technology Mission Directorate (STMD)

ABSTRACT

Photocatalysis is a process in which light energy is used to ‘activate’ oxidation/reduction reactions. Unmodified titanium dioxide (TiO2), a common photocatalyst, requires high-energy UV light for activation due to its large band gap (3.2 eV). Modification of TiO2 can reduce this band gap, leading to **visible-light-responsive (VLR)** photocatalysts. These catalysts can utilize solar and/or visible wavelength LED lamps as an activation source, replacing mercury-containing UV lamps, to create a “greener,” more energy-efficient means for air and water revitalization. Recently, KSC developed several VLR catalysts that, on preliminary evaluation, possessed high catalytic activity within the visible spectrum; *these samples out-performed existing commercial VLR catalysts.*

<u>Project Goals:</u>

Develop rugged reactor test bed for catalyst testing with exchangeable light sources.

Optimize KSC-developed VLR-catalysts to treat recalcitrant trace contaminants found in closed-loop air systems such as ISS.

Advance TRL to align with AES goals for FY16/17 scale-up testing.

ANTICIPATED BENEFITS

To NASA funded missions:

<u>Return on Investment:</u>

Multiple commercial applications for fresh fruit/vegetable preservation, air purification, water purification, possible antimicrobial technology.

Possible patentable technology (multiple New Technology

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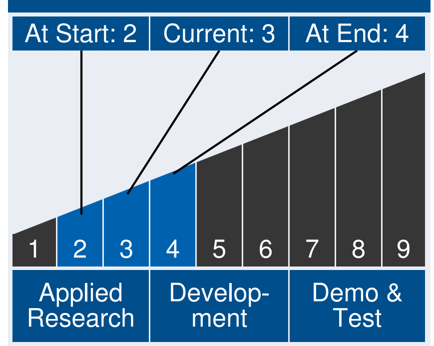
Technology Maturity



Reports will be filed on this work).

Ability for KSC to garner funding from Advanced Exploration Systems (AES) for future testing of technology.

Continued development of VLR-PCO systems will pave the way to a future standard for trace contaminant control in aerospace crew cabins. This project will reduce the complexity (no ballasts), life cycle costs (longer lamp life/lower disposal costs), and environmental impact (no Hg; less power) of existing PCO systems, while increasing the reliability (LEDs) and safety (no UV or Hg) of such systems.

Photocatalysis of trace gas contaminants is only one application for this technology. Utilizing data gathered from this study, these VLR catalysts could also be used to treat water contaminants (e.g., endocrine disruptors), and problems involving microbial contamination in air, water, and food. The spaceflight applications go well beyond trace contaminant control in crew cabins (e.g., ethylene control in future plant production life support systems), but the real societal benefits are likely to come from the diverse commercial applications of the technology.

To the commercial space industry:

This technology has the potential for more efficient, safer trace contaminant control in spacecraft which will benefit the commercial space industry.

To the nation:

Photocatalysts that utilize visible light allow them to use solar radiation on the Earth's surface. This is a great benefit to the nation and the world as it could be a method for removing contaminants from air and water using renewable energy.

Realized Benefits

1 Conference Paper

Management Team

Project Manager:
- Nancy Zeitlin

Principal Investigator:
- Paul Hintze

Co-Investigator:
- Janelle Coutts

Technology Areas

Primary Technology Area:
Human Health, Life Support & Habitation Systems (TA 6)
└ Environmental Control & Life Support Systems & Habitation Systems (TA 6.1)

Other Technology Areas:
- Ground & Launch Systems Processing (TA 13)
- Environmental and Green Technologies (TA 13.2)

DETAILED DESCRIPTION

The knowledge gained from this research will inform continued advancements in trace contaminant control. The research will provide insight on the ability to utilize visible-light-induced photocatalysis for the safe removal of volatile organic chemicals. This project will advance a much needed remediation technology, throught the following tasks:

Task 1: Development of reactor test bed and LED array.

1. Modification and development of a current catalyst test bed including rugged reactor design and in-line monitoring of contaminants to determine photocatalytic activity.
2. Development of a visible wavelength LED array for comparison of light source choice in experiments.

Task 2: Optimization and testing of top-performing catalysts.

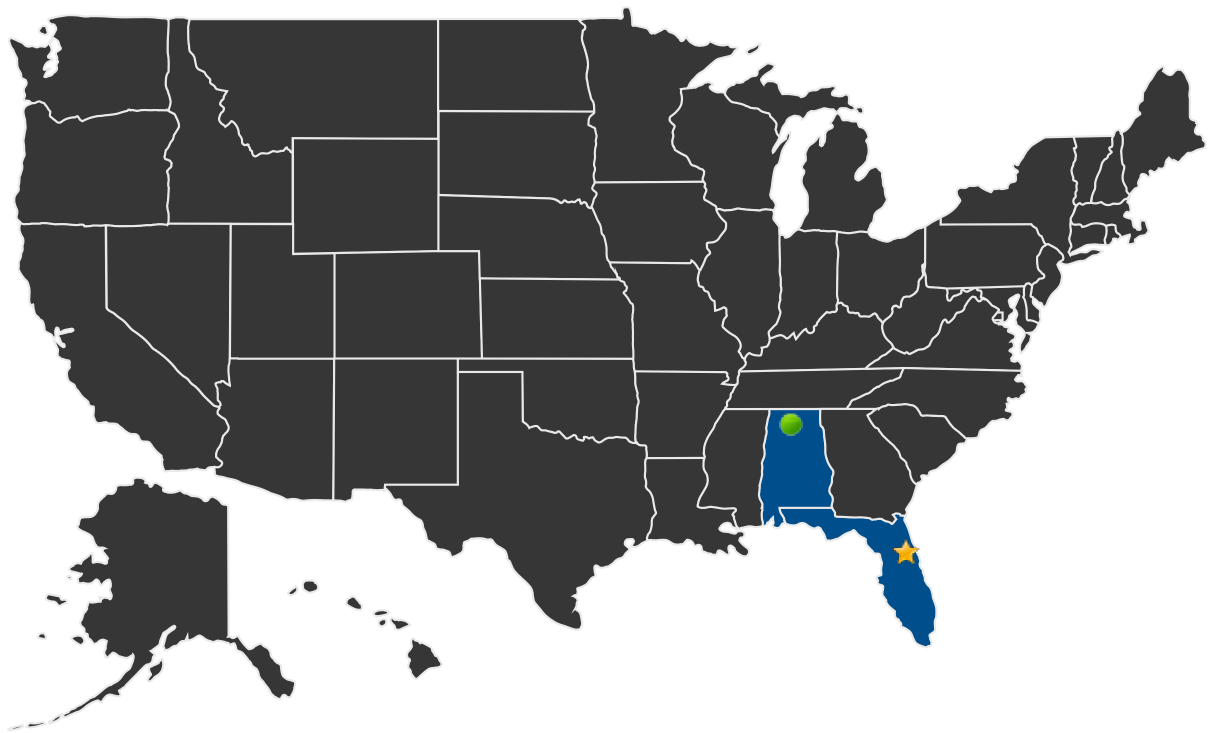
1. Optimization of catalyst formula and immobilization techniques for catalyst evaluation.
2. Completion of catalyst evaluation including ability to degrade multiple challenge contaminants, catalyst lifetime, etc.
3. Evaluation of effective light sources for photocatalytic work to achieve independence from Hg-containing lamps.

Task 3: Physical characterization of catalysts.

1. Analysis of physical characteristics including, but not limited to, XPS, diffuse reflectance, BET surface area, SEM, etc.

Task 4: Evaluation of technology for validation in relevant environments such as HISEAS or similar.

U.S. LOCATIONS WORKING ON THIS PROJECT



U.S. States With Work

Lead Center:
Kennedy Space Center

Supporting Centers:

- Marshall Space Flight Center

Other Organizations Performing Work:

- Engineering Services Contract

Contributing Partners:

- University of Central Florida (UCF)

PROJECT LIBRARY

Conference Papers

- Visible-Light-Responsive Catalysts Using Quantum Dot-Modified TiO2 for Air and Water Purification
  - (http://repositories.tdl.org/ttu-ir/bitstream/handle/2346/59639/ICES-2014-28.pdf?sequence=1)

DETAILS FOR TECHNOLOGY 1

Technology Title

Visible Light Responsive Catalysts

Technology Description

This technology is categorized as a material for manned spaceflight

New photo-catalysts have been developed that are responsive to visible light and are perform better than existing catalysts. When used in a photocatalytic oxidizing reactor for cleaning air and water, these catalysts can be exited with visible LED lights, or sun light, instead of UV lights which are harmful to humans and often contain mercury.

Capabilities Provided

The catalysts have been shown to oxidize trace contaminants in water and air when illuminated by visible light.

Potential Applications

The catalysts are currently being implemented into a prototype system that will clean air of volatile organic carbon. The current target application is air cleaning on the International Space Station or a different crewed space vehicle. Other applications include water cleanup, or terrestrial applications were sunlight can be used as the light source.