CESO 22-2: Plasma Treatment of Volatile Organic Compounds (VOCs)

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Start TRL: 2 **End TRL:** 4

Prime Taxonomy:

TX07.2.1 Logistics Management

Secondary Taxonomy:

TX06.1.1 Atmosphere Revitalization, TX06.1.3 Waste Management

KSC Focus Areas:

J3: In-Space Logistics Mass Reduction, J5: Closed Loop System Development, R1: In Situ Atmosphere/Gas Resources, R4: Recovery of Liquids and Gases, C7: Environmentally friendly remediation of hazardous waste

Project Description:

Plasma is an energetic source that has thermal and non-thermal chemistry applications. For this work, we pursued the investigation of plasma as a non-consumable based method of treating spacecraft volatile organic compounds (VOCs) in order to mitigate or eliminate potential hazards. This work focused on select compounds but also applied the technology to program-funded trash-to-gas (TtG) effluent gas.

Benefits:

The use of plasma to decompose gaseous compounds into simpler ones allows for potential treatment and handling of spacecraft VOCs. This work has also branched into waste management technologies, with continued work expected to mitigate the produced concentrations from TtG effluents into allowable concentrations or simpler compounds that can be vented safely**.**

Executive Summary:

Plasma systems were used to break down VOCs into simpler components. This project focused on VOCs that are a subset of those listed on the published Spacecraft Maximum Allowable Concentrations (SMAC) list for airborne contaminants. VOCs are gases that can be damaging to both humans and the environment. Currently, VOCs that are produced by various space technologies must be scrubbed with consumable filters or vented out into space. Plasmas provide high energy electrons and ions that are capable of breaking down gaseous organic species into smaller compounds. The use of plasma to treat VOCs has the potential to preserve resources and mitigate harmful contaminants for future crewed missions. In the initial study with a 4-standard liter per minute (SLM) recirculation pump, the DC plasma conversion of all analytes followed first-order rate kinetics and effectively eliminated 4 selected VOCs by > 99% within 10 minutes of treatment (acetone, benzene, ethanol, pentane). Using the same methods described herein but with a new 15 SLM recirculating pump, the DC plasma eliminated the selected VOCs by > 99% within 2 minutes. The higher flow rate facilitated the plasma breakdown of all analytes in less time by increasing the probability of interactions between the gases and the plasma. Also, the higher flow rate is better suited for the discharge geometry, thus increasing the volume of the plasma. Additionally, in a background of CO_2, the plasma-based conversion of CO_2 into O_2 and CO was observed.