National Aeronautics and Space Administration

NASA

TECHNOLOGY SOLUTION

Mechanical and Fluid Systems

Extractor for Chemical Analysis of Lipid Biomarkers in Regolith (ExCALiBR)

An autonomous, miniaturized fluidic system for lipid analysis

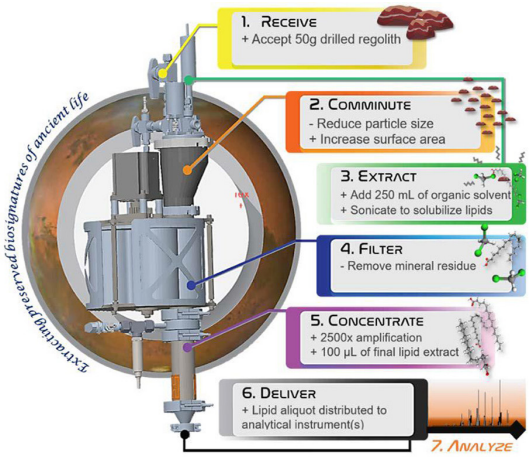
Lipids are organic molecules used by all life on Earth, primarily for building membranes that encompass cells. The analysis of lipid biomarkers has gained increasing importance within environmental and archaeological fields because biomarkers are representative of particular plant and animal sources. Proven “gold standard” laboratory techniques for lipid biomarker extraction are laborious, with many opportunities for human error. As a solution, NASA Ames Research Center has developed a novel technology that provides an autonomous, miniaturized fluidic system for lipid analysis. The technology, in a single instrument, can accept an unprocessed soil, rock, or ice sample, comminute the sample, extract lipids via sonication and blending, filter out mineral residue, concentrate the analyte, and deliver the aliquot to downstream analytical instruments for molecular characterization, without requiring intervention from a human operator.

BENEFITS

- Conserve origin-diagnostic lipid structures/patterns by maintaining them in the liquid phase
- Reduce signal-to-noise interference by extracting lipids from the mineral matrix and filtering out minerals
- Reduces potential for contamination during sample handling and processing
- Combines the seven steps within sample collection, extraction, filtration, and chemical preparation for downstream analysis into one instrument
- Saves cost and time - operator independent; and what previously required a human ~8 hours to complete would now take only ~1-2 hours
- Performance benefits: e.g., lower labor hours, more automation, reduced consumables, quick turnaround for sample analysis, and allowance for measurements at field site
- Prototype was fabricated from commercial off-the-shelf (COTS) parts
- Can be deployed on other planetary surfaces with simple modifications to extraction parameters such as solvent polarity, temperature and pressure

THE TECHNOLOGY

The technology provides miniaturized techniques for extracting trace amounts of organic molecules (lipids) from natural samples. It operates as an autonomous, miniaturized fluidic system, integrating lab techniques for lipid analysis while minimizing reagent volumes and concentrating organics for analysis, thereby increasing signal-to-noise ratios by orders of magnitude. The non-aqueous fluidic system described herein for astrobiological and life-detection missions (either in situ or returned sample) is configured to extract lipid organics from regolith using (1) a fluidic sample processor made of materials compatible with organic solvents and (2) a machine-learning system to select processing steps and parameters to maximize lipid yield. A critical gap is bridged by integrating technologies into a system that replicates analytical lab procedures autonomously on a spaceflight instrument scale with fidelity to original lab techniques. Automated fluidic devices combine controlled handling of liquids with sequential operations and parallelization of replicate processes. By designing such systems to closely interface with both sample-delivery and analytical measurement systems, laboratory analyses are automated. The technology adapts best practice laboratory methods for lipid analysis, overcoming analytical challenges like low organic abundance, interference of minerals/salts, and degradation of origin-diagnostic molecular structures. The extraction and concentration techniques from rock/soil samples can be applied to any biomarkers by changing the solvent, temperature, and agitation.



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APPLICATIONS

The technology has several potential applications:

- Oil and petroleum industry - analyzing oil trapped in geological deposits and exploration technologies
- Petroleum protecting, both in the area of unconventional oil and gas where micro-scale matters, as well as for sub-sea deployment systems and borehole environments
- Can be used to detect lipids in Earth soil to determine presence of petrochemicals; to detect oil spills or other contamination
- Life detection in an astrobiologically significant sample in future missions to Mars, Enceladus, and/or Europa
- Analysis of natural, complex organic material preserved in soils and rock
- Integrated into benchtop analysis or onto an unmanned terrestrial rover for field exploration
- Integrated into an aquatic system for petroleum studies with only minor modifications

PUBLICATIONS

Patent Pending

https://ui.adsabs.harvard.edu/abs/2021LPI....52.2634W/abstra

technology.nasa.gov

NASA's Technology Transfer Program pursues the widest possible applications of agency technology to benefit US citizens. Through partnerships and licensing agreements with industry, the program ensures that NASA's investments in pioneering research find secondary uses that benefit the economy, create jobs, and improve quality of life.

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More Information

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Agency Licensing Concierge

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