

HYPEB

Liquid Nitrogen poured over a pile of lunar dust simulant creating a cryoclastic flow.

Liquid cryogen dusting effectively mitigates lunar dust simulant. Extensive testing demonstrates technology efficacy above OUTRO 90% removal for particles smaller than 10 μm. Liquid cryogen dusting warrants further research and development to provide a viable lunar dust mitigation solution by 2026 for the NASA Artemis missions.

# Leidenfrost Dusting as a Novel Tool for Dust Mitigation

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#### INTRO

Lunar dust prevents nominal lunar activity. Current mitigation technology is ineffective and inefficient. Liquid cryogen sprays were investigated to accomplish lunar dust cleaning using lunar habitat resources. The proposed system consists of a spray-bar for general cleaning and a handheld liquid cryogen sprayer for spot treatment.

### TRL 3

- Benchtop proof of concept and validation in laboratory environment.
- Single nozzle liquid cryogen sprayer.
- Large fabric swatches.
- 492 trials.

# TRL 4

- Validation in relevant environment.
- Vacuum chamber.
- Single spray nozzle.
- Small fabric swatches.
- 82 trials.

# TRL 5

- Scale prototype demonstration in relevant environment.
- Vacuum chamber.
- Spray-bar.
- 1/6 scale astronaut.
- Results comparable to TRL 3 and TRL 4.
- 18 trials.







	Parameter	<b>Optimal Value</b>	Mean Mass Removal (%)	Confidence Interval (95%)
	Angle of Inclination	≤ 90°	93.9	±0.58
	Distance of Spray	≥ 40 cm	96.6	±0.30
	Application Time	30 s	97.0	±0.25
	Less than 10 µm	90°, 40 cm, 30 s	92.4	±0.65
<image/>	Maximum LN2 Usage	$\geq 10 \ \frac{\text{kg}}{\text{m}^2}$	~100.0	-2.75
	Nozzle Type	Flat	98.4	±0.99
	Less than 10 µm	Flat, 10 s	95.9	±2.12

#### MORE



- in Lunar gravity.



• Mount Saint Helens ash as lunar dust simulant.

• Nomex-Kevlar Ripstop as spacesuit simulant.

• Simulant removal verified against standards.

• Mass fraction as removal measurement.

 Dynamic light scattering and microscopy gave particle size distribution.

Numerical modeling indicates Leidenfrost effect

Consumes 435 W\*h per full wash (liquefaction).