ISRU Antiviral Ceramic Coatings Using ZnO Lunar Regolith Composites for Space Habitats

Antiviral ceramic coatings use lunar soil to protect space habitats and high-touch surfaces, reducing the weight and cost of antimicrobial materials launched from Earth.

Space habitat and spacecraft operators lack proven antiviral surface solutions tailored for long-duration missions, while every kilogram of antimicrobial payload shipped from Earth adds cost and logistics risk. This invention introduces antiviral ceramic composite coatings that combine tetrapod-shaped ZnO with lunar regolith (simulant), enabling in-situ resource utilization (ISRU) to reduce mass while suppressing virus persistence on high-touch surfaces. Unlike Earth-supplied antimicrobial films (e.g., Ag/Cu or photocatalytic oxides) that are not optimized for space thermal-vacuum, radiation, dust exposure, or ISRU workflows, these ZnO regolith composites leverage morphology-driven ionic ceramics and regolith chemistries to inactivate viruses. In ISO 21702-aligned benchtop tests (4-hour exposure) against both an enveloped coronavirus (OC43) and a non-enveloped calicivirus, select compositions outperformed controls: 50/50 ZnO highland showed the strongest activity; pure mare simulant was a close second; pure ZnO also performed well, while pure highland simulant showed anomalous readings likely tied to surface morphology. The current stage is benchtop coupon validation with multiple compositions; next steps include durability and efficacy under space-relevant conditions (thermal-vacuum, radiation, dust/abrasion) and process tuning for low-temperature coating. If successful, this platform could improve operational hygiene and mission resilience in space habitats and spacecraft, with spillover potential for durable terrestrial antiviral surfaces.

Technology Validation

Coupons consisting of tetrapod-ZnO, lunar regolith simulants (highland, mare), and their mixtures were tested under ISO 21702 conditions against OC43 (enveloped) and feline calicivirus (non-enveloped) at 4-hour exposure. 50/50 ZnO highland and pure mare simulant exhibited the highest antiviral

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response; pure ZnO also exceeded controls, while pure highland simulant produced anomalous readings attributed to non-ideal surface morphology. These results constitute proof-of-concept, lab-scale validation with activity across distinct virion architectures.

Advantages

-ISRU-ready mass savings: Uses lunar regolith as a functional component, reducing reliance on Earth-launched antimicrobial payloads.

-Broad-spectrum efficacy: Demonstrated activity versus enveloped and non-enveloped viruses under ISO 21702-aligned testing.

-Space-compatible durability: Ceramic platform expected to better tolerate thermal-vacuum cycling, radiation, and dust than many organic films.

-Manufacturing flexibility: Compatible with existing low-temperature and room-temperature coating/printing methods; no new platform required.

-Path to qualification: Standards-aligned testing supports industry translation and future environmental durability qualification.

Applications

-Space habitats/stations: High-touch interior panels, handrails, work surfaces for commercial and government habitats.

-Lunar infrastructure: Coatings for regolith-derived habitat components and tools fabricated via in-space manufacturing.

-Spacecraft/rovers: Cabin touchpoints, tools, and fixtures with constrained cleaning cycles.

-Terrestrial spillover: Durable antiviral ceramics for healthcare fixtures, public transit touchpoints, and mission-critical control rooms.

TRL: 4

Intellectual Property:

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