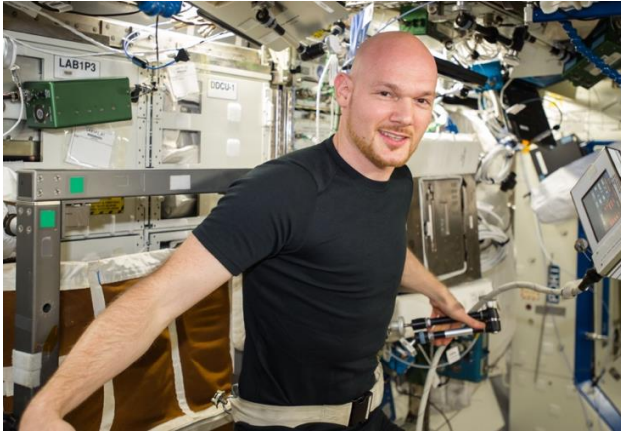


Space Environment Clothing



Name of Technology:

Clothing for Enriched Oxygen Atmospheres

Participating NASA Centers:

JSC (Lead)

Technological Area:

T6.08 Textiles for Extreme Surface Environments and High Oxygen Atmospheres

Vision for the Technology:

Exploration crews will need comfortable clothing for long-term missions while maintaining non-flammable functionality. Future exploration spacecraft will operate at higher Oxygen (O_2) levels and lower pressures. For crew safety, clothing is needed that will not ignite under nominal atmospheric conditions.

Challenges:

Currently, the International Space Station (ISS) atmosphere is at 21% O_2 at 14.7 psia, making the crew clothing susceptible to flammability. Future spacecraft will be operated at lower pressures and corresponding to higher O_2 (30% O_2 at 10.2 psia and 36% O_2 at 8.3psia). Clothing becomes even more of a fire hazard under these elevated O_2 conditions. Cotton clothes worn are flammable at 21% O_2 at 14.7 psia. Current areas of consideration:

- Inherently flame-retardant textile fibers such as the 1.5 denier polybenzimidazole (PBI) fiber is the only inherently flame-retardant fiber commercially available to make yarns for apparel fabrics.

- There are several polymers that meet the flame-retardant threshold of 36% oxygen at 14.7 psia, but few have been used to produce textile fibers. Among those that are currently spun into fibers like polyimide, the fibers are mostly used to make yarns and fabrics for industrial applications.
- A durable flame-retardant treatment may be considered to apply to fibers, yarns, or fabrics.
- Most existing textile fibers that do not support combustion in 36% oxygen-rich atmosphere have too large diameter of fibers, and consequently, the fibers bending, and torsional properties are not adequate to produce yarns suitable for knitted garments.
- Comfort, both softness and warmth, is a function of yarn hairiness. However, greater hairiness promotes flammability. Flame-retardant treatments reduce hairiness and reduces comfort. It would be favorable to use inherently flame-retardant fibers over a flame-retardant treatment.
- Volatile free fabrics materials are important to crew health.
- Minimal amount of lint.
- The fabrics shall not produce malodor.
- Fabrics shall be resistant to wear from the abrasive lunar regolith particles.

NASA Seeks to Meet the Following Specs:

Successful closure of this gap will be determined through:

- ❖ Flame Retardance
 - Non-flammable at 40% O_2
 - Inherently flame-retardant textile fibers
 - Durable flame-retardant treatments
- ❖ 50 laundry cycles
- ❖ Comfort
 - Soft to skin
 - Outside flame retardant
- ❖ Volatile Emissions
 - Free of volatile materials
- ❖ Lint Reduction
 - Minimal amount of lint
- ❖ Odor Control
 - Shall not produce malodor
- ❖ Resistance to the lunar regolith
 - Withstand wear abrasion

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Overview of Student Project:

NASA seeks innovative fabric solutions that will provide comfortable clothing for long-term missions while maintaining non-flammable functionality. For crew safety, clothing is needed that will not ignite under higher Oxygen (O₂) levels and lower pressures (30% O₂ at 10.2 psia and 36% O₂ at 8.3psia).

Innovative Areas Student Projects Can Address:

- ❖ Flame-retardant clothing including inherently flame-retardant textile fibers
- ❖ Durable flame-retardant treatments for fibers that are still comfortable

Project Phases

- I. Conceptual and feasibility study with characteristics
- II. Proof of Concept/Prototype in lab environment

Research Funded by NASA on this Topic:

Proposal Number: 21-1- H3.07-2719
[Nanolayer-Coated Flame-Retardant Fabrics for Space Crew Clothing](#)

Proposal Number: 21-1- H3.07-2484
[Flame Retardant Textile Treatments for Crew Clothing](#)

Proposal Number: 21-1- H3.07-3144
[Flame Retardant Polyamide Fibers for Space Crew Clothing](#)

Proposal Number: 08-1 X2.05-9325
[Comfortable and Durable Clothing Ensemble with Flame-Resistant Properties](#)

Proposal Number: 09-1 X2.04-9618
[Non-Flammable Crew Clothing Utilizing Phosphorus-Based Fire Retardant Polymers](#)

Proposal Number: 96-1 16.03-6000
[Flame Resistant Space Crew Clothing Using an Environmentally Friendly Surface Treatment](#)

References:

[T6.08 Textiles for Extreme Surface Environments and High Oxygen Atmospheres](#)

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