



## NASA SBIR 2021 Phase I Solicitation

### H3.07 Flame-Retardant Textiles for Intravehicular Activities (IVA)

Lead Center: JSC

Participating Center(s): GRC

Scope Title:

**Flame-Retardant Textiles for Crew Clothing and for Use in Spacecraft Cabins**

#### **Scope Description:**

There is a textile technology gap for apparel fabrics for lunar and planetary human exploration. While there are industrial fabrics that are flame retardant in oxygen-enriched atmospheres up to 100% at ambient pressure, there is no apparel or furnishing fabric that is flame retardant in enriched atmosphere of 36% oxygen at a pressure of 8.2 psi (56.5 kPa). The challenge for developing next-to-the-skin flame-retardant fabrics comes from the many other requirements these fabrics must satisfy. They must be comfortable. This means they must have high drape, be soft to the touch, and have no inherent unpleasant smell. In addition, they cannot be toxic through the skin or outgas toxic chemicals. These fabrics must be washable and durable over a period of up to three years of repeated use. In other words, these fabrics must have physical and mechanical properties (no static cling, color fastness, tensile strength and elongation dry and wet, tear resistance, bending stiffness, torsional stiffness, abrasion resistance, etc.) that make them suitable for use in T-shirts and pants to be worn in an atmosphere containing 36% oxygen. NASA needs such new fabrics to send astronauts to the Moon in order to later establish a sustainable human presence beyond low Earth orbit (LEO) or on the Moon, and in preparation for a future trip to Mars.

The gap in textile technology that affects IVA results from the need to protect astronauts inside space vehicles and space habitats with atmosphere of  $34 \pm 2\%$  oxygen at a pressure of 8.2 psi (56.5 kPa). During the period the astronauts reside in the Lunar Lander, they will need fire protection provided by their clothing as they will not continuously wear their space suits during the entire period the lander is on the Moon.

**Expected TRL or TRL Range at completion of the Project:** 1 to 3

#### **Primary Technology Taxonomy:**

Level 1: TX 06 Human Health, Life Support, and Habitation Systems

Level 2: TX 06.1 Environmental Control & Life Support Systems (ECLSS) and Habitation Systems

#### **Desired Deliverables of Phase I and Phase II:**

- Research
- Analysis
- Prototype

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**Desired Deliverables Description:**

In Phase I, the deliverable should be a report demonstrating the feasibility to produce new flame-retardant, nontoxic apparel fibers and/or finishing treatments on existing fibers that do not support combustion in an atmosphere of 36% oxygen at a pressure of 8.2 psi. The chemical process for developing a synthetic fiber or a finishing treatment, including any test results, should be fully described to understand any toxicity issue related to processing. Furthermore, the researchers should describe the rheological, physical, and mechanical properties of the new fiber or finishing treatment and explain how these properties will make these fibers suitable for apparel applications.

In Phase II, the deliverable should be a fiber that can withstand the production processes used in the textile industry. The researchers should therefore process the new fiber and experiment with different processing conditions to determine which conditions will lead to consistent results that will enable scaling-up production. In other words, the researchers must demonstrate that they can make fine yarns that will not break or produce excessive lint when woven into fabrics. It is highly desirable that samples of fabrics be developed and evaluated.

**State of the Art and Critical Gaps:**

The state of the art in flame-retardant apparel fibers and fabrics for use next to the skin is mostly represented by meta-aramids, modacrylic, and flame-retardant (FR) fibers (FR rayon, FR wool, etc.). These fibers will not support combustion in air, but they burn in an atmosphere of 36% oxygen.

The critical gap is the absence of an inherently strong, flame-retardant (in 36% oxygen), nontoxic, and comfortable fiber to use for next-to-the-skin clothing.

**Relevance / Science Traceability:**

This work will benefit several space programs, namely the lunar Human Landing System (HLS), Orion, Gateway, and Artemis, enabling the astronauts to function in habitats, pressurized rovers, and other space vehicles with enriched oxygen atmospheres and to shorten prebreathe times prior to extravehicular activities (EVAs).

**References:**

NASA imagery collection of crew clothing in the Skylab Project. Nonflammable clothing development program, Richard Johnston and Matthew I. Radnofsky, Fire Technology 4, 88-102 (1968) [https://airandspace.si.edu/collection-objects/jacket-skylab-2-kerwin/nasm\\_A19772817000](https://airandspace.si.edu/collection-objects/jacket-skylab-2-kerwin/nasm_A19772817000)