

## Flame Retardant Fibers for Human Space Exploration – Past, Present, and Future

The National Aeronautics and Space Administration (NASA) has led the development of unique flame retardant fibers for the specific requirements of different space programs. Three of these fibers have greatly contributed to the safety of all the space missions since the Apollo program. Beta alumina-silica microfiber developed for the outer layer of the space suit after the Apollo 1 fire is no longer used and has been replaced by other glass fibers. Expanded polytetrafluoroethylene (e-PTFE) fiber used in the current spacesuit is mostly known today through its trade mark Gore-Tex®. Polybenzimidazole (PBI) filament fiber used in many applications from the Apollo to the Space Shuttle program is no longer available. More recently, TOR™ copolymer of polyimide fiber developed during the space shuttle program to resist the atomic oxygen present in Low Earth Orbit has been barely used. The high cost and narrow range of aeronautical and aerospace applications have, however, led to a limited production of these fibers. Only fibers that found niche markets survived. Yet, deep space exploration will require more of these inherently flame retardant fibers than what is available today. There is a need for new flame retardant fabrics inside the space vehicles as well as a need for logistics reduction for long term space missions. Materials like modacrylic and polyimide are good candidates for future flame retardant aerospace fabrics. New fabrics must be developed for astronauts' clothing, as well as crew quarters and habitat. Therefore, both staple and filament fibers of various linear densities are needed for a three years mission to Mars.