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Thermal, Ultraviolet and Hydrothermal Aging of Para-Aramid/Polybenzimidazole Fire-Protective Fabrics

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ABSTRACT

High-performance fibers are used in firefighters' protective clothing, for oil and gas industry workers, and whenever protection is needed against heat and flame. In addition to protection against exposure to the various hazards, the protective clothing has to maintain its performance over time while it is exposed to various damaging conditions such as heat, ultraviolet (UV) radiation and moisture. Although high-performance fibers are known for their excellent strength and thermal resistance, they are somewhat sensitive to weathering conditions such as extreme temperature, UV and moisture. This study exposed a fire-protective fabric composed of a blend of para-aramid and polybenzimidazole (PBI) fibers to thermal, UV and hydrothermal aging conditions. For the thermal condition, the specimens were exposed to different temperatures between 90°C to 320°C for up to 1200 hours. For the UV condition, the specimens were subjected to combined thermal, and UV radiation ranges between 50°C to 80°C for irradiance between 0.68 W/m^2 to 1.35 W/m^2 for up to 600 hours. The hydrothermal aged specimens were collected after immersion in water at different temperatures between 60°C and 90°C for up to 1200 hours. The residual tensile strength of the fabrics was measured after aging in different exposure conditions and times. The experimental data show that the strength of fabrics made of para-aramid /PBI fiber blends is severely reduced after thermal, UV and hydrothermal aging. The residual strength data of the fabrics was analyzed by the time-temperature superposition principle, followed by the extraction of the activation energy from the Arrhenius plot. The analysis provides quantitative information to compare the resistance of different fabrics to weathering and estimate their service life. The FTIR analysis revealed chemical changes in specimens due to thermal aging, but no evidence of chemical changes was observed for UV and hydrothermally aged specimens. In addition, morphological changes were observed in thermal and UV aged specimens, while not for hydrothermally aged specimens. The study provides an insight into the aging behavior of para-aramid/PBI blend high-performance fabrics used in protective clothing against heat and flame. The results obtained can also be used to support the development of end-of-life sensors and predictive models of the aging of fire-resistant fabrics.

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