

Ultraviolet Radiation Protection of a Naturally Colored Lightweight Cotton Fabric

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Significance of the study and application of relevant literature. Overexposure to ultraviolet radiation (UVR) can (a) result in harmful effects on human skin (sunburn, ageing), (b) cause DNA damage, (c) lead to genetic changes and immune system modulation, and in the worst case, (d) advance to the development of skin cancer (Narayanan, Saladi & Fox, 2010). More than three million cases of skin cancer are diagnosed each year in the United States, and the number of skin cancer patients is greater than the combined total number of patients with breast, prostate, lung, and colon cancers (Rogers, Weinstock, Feldman & Coldiron, 2015). To reduce an individual's risk of skin cancer, the Centers for Disease Control and Prevention, a leading national public health institute in the United States, suggests that one's covering up with clothing and hat is a simple way of practicing sun safety ("What can I do," 2014).

Compared to other fibers, cotton is considered more comfortable to wear in the summer months because it has excellent breathability and moisture absorbency; however, conventional cotton generally has very low UVR protection. According to Smith (1993), a common white cotton T-shirt has an Ultraviolet Protection Factor (UPF) rating of seven when dry, and a rating of five when wet. A minimum UPF value of 15 is required to classify a textile as "sun protective," according to the ASTM Test Method D6603, Standard Guide for Labeling of UV-Protective Textiles. Because natural pigments and lignin in naturally colored cottons (NCC) can act as UVR absorbers, fabrics made of NCC provide better UVR protection than conventional cotton (Parmar, Giri, Singh, & Chhabra, 2006). For example, in Parmar et al. (2006) NCC fabrics had a UPF rating of 28 and 29, which were high enough for a rating of "Very Good Protection" (UPF of 25 to 39) based on the ASTM sun protection label. Therefore, NCC fabrics are a better choice for clothing worn in summer months than are conventional cotton fabrics.

Since summer clothing is subject frequent washings, it is important to understand whether a NCC fabric will retain its UVR protection property after perspiration absorption, weathering exposure, and laundering process. No study has been found that examined these effects, and therefore the purpose of this study was to examine the effects of perspiration, weathering exposure, and repeated laundering on UVR protection of a NCC lightweight fabric that is suitable for summer clothing.

Method. The research design used in the current study was a repeated measures experimental design with 2 perspiration (perspiration and no perspiration) x 3 weathering exposure (semi-tropical climate found in South Florida, which is hot and humid; semi-arid climate found in Phoenix, Arizona, which is hot and dry; and the standard textile testing condition served as a control), and repeated measures before and after each laundry cycle, up to 15 cycles. A plain weave, light tan and lightweight (3.5 oz/yd²) NCC fabric was selected as the test fabric. The UPF value was 45.06, which is categorized as "Excellent Protection" (UPF of 40 or above), based on

the ASTM sun protection label. Before conducting any treatments or measurements, the specimens were conditioned for at least six hours according to the ASTM D1776. The perspiration treatment was conducted according to the ASTM D1776, the weathering treatment was performed based on the AATCC Test Method 169, and the specimens were washed according to AATCC Test Method 135. Before and after each laundering and drying cycle, the UVR protection (indicated by the UPF value) of the test specimens was measured in accordance with the AATCC Test Method 183.

Results and Discussions. The test of repeated measured ANOVA was used to analyze the data. Significant interactions among the two treatments and laundering were found ($F=3.78$, $p<.001$). Further analysis showed that the UPF values of the specimens without weathering increased as the laundering cycles increased, with and without treatment of perspiration ($F =77.15$, $p<.001$), and changed from 45.06 to 57.51 (perspiration) and 56.71 (no perspiration) after 15 laundry cycles. Weathering significantly reduced the UPF value ($F=57.65$, $p<.001$), and the semi-tropical climate caused more reduction than the semi-arid climate ($M=25.26$ and 27.45). Perspiration slowed down the protection decline ($F=323.85$, $p<.001$). In the specimens treated with artificial perspiration, no significant difference was found between the specimens exposed to the two climates ($M=28.56$ and 29.33). However, in the specimens without perspiration treatment, the UPF value of the specimens exposed to the semi-tropical, hot and humid, climate was lower than the specimens exposed to the semi-arid, hot and dry, climate ($F=93.18$, $p<.001$; $M=21.96$ and 25.57). After 15 laundry cycles, the UPF value of the specimens exposed to the semi-arid climate was 13.37, which, being lower than 15, could not be categorized as a sun protective fabric.

This study provided insights into how perspiration, weathering and repeated laundering influence UVR protection of a NCC lightweight fabric that is suitable for summer clothing. The findings showed that laundering without weathering increased the protection, whereas weathering significantly reduced the protection. The high humidity in the semi-tropical climate facilitated the decline of protection, but perspiration played a role in slowing down the reduction. The lowest UPF value after 15 laundering cycles was found in the specimen after the exposure to a hot and humid climate without perspiration treatment. The test fabric changed from a category of “Excellent Protection” before testing to the rating that no longer could be labeled as UVR protective.

Reference

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