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Simplifying Fabric Flammability Measurements for Use in Public Health Practice

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Abstract

Fire behavior of textiles varies depending on fiber composition, manufacturing process and any additional treatments applied. Such variables can contribute to significant differences in the flammability making it difficult to estimate the risk of fire ignition. Clothing fires can cause burns with minor injuries and burns leading to serious injuries that may require hospitalization. The elderly and children are especially at risk since they may not recognize the dangers of a clothing fire and how to react quickly to extinguish the flames. Health and safety professionals are frequently asked to recommend reducing such risks. However, information about the flammability properties of non-FR treated clothing worn by the public is generally not available. The objective of this research program was to develop a simplified method for defining the flammability of commercially available fabrics. 50 samples were tested including Cotton, Wool, Silk, Nylon and Polyester. Changes in the weight of a sample resulting from combustion including the time involved in the combustion cycle was used as a indictor of the total heat generated by the fire and the risk and severity of a burn injury. The results showed that the Cotton and Wool fabric samples created the highest risk of burn injury while the Polyester fabric created the lowest risk. These conclusions are based on two criteria: Total time associated with a combustion cycle and the loss of fabric mass during the combustion cycle. The proposed method can be carried out using a standard laboratory fume-hood, a precision weight scale and a stopwatch.

Keywords: Fabric Fires; Fabric Flammability Assessment; Risk of Burn Injuries; Public Health

1 Background

Clothing fires are a significant public health challenge globally. Thousands of deaths and injuries occur each year from the ignition, propagation and smoldering of flames in clothing. Approximately two million persons suffer burn injuries each year and over 100 000 require hospitalization [1, 2]. Burn injuries caused by ignited clothing are most prevalent among young children and

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the older populations [3, 4]. All fabrics will burn to varying degrees if exposed long enough to a flame. However, the fiber content, construction, fabric weight and fabric finish can influence their flammability characteristics. The same fiber used in different fabrics can burn at different rates. Use of Nano-materials in the future will likely present additional challenges in characterizing the flammability of clothing.

Standards related to fabric flammability testing have been developed by organizations such as the International Organization for Standardization (ISO), the American Society for Testing and Materials (ASTM) and the National Fire Protection Association (NFPA). Examples of standards that address minimum performance requirements include firefighter protective clothing [5, 6] and clothing used by industrial workers [7, 8]. Some standards address fabric flame spread [9, 10] and clothing used for extreme exposures [11, 12].

The severity of skin injury caused by an exposure to a fabric fire is proportional to the total heat transferred to the skin and the duration of the flaming cycle [13, 14]. The risk of injury can be estimated by observing the duration of the flaming cycle and measuring the fabric mass (weight) consumed by the fire. While fire exposure guidelines employ thermodynamic variables, such guidelines primarily apply to protective clothing used in high-risk occupational settings [15]. The flammability ratings of commercially available clothing worn by the public are generally unavailable. A simplified method for testing the flammability of commercially available fabrics is proposed which can provide relative comparisons among and between different fabric materials. This approach will allow health and safety professionals to "rank order" consumer relevant fabric materials from "least" flammable to "most" flammable when considering the availablilty of multiple fabric types.

2 Methods and Procedures

2.1 Fabric Samples

Five types of fabric material were evaluated, including 10 samples of Silk (100%), 10 samples of Polyester (100%), 10 samples of Nylon (100%), 10 samples of Cotton (100%), and 10 samples of Wool (100%). Each sample tested was 20 cm in length and 5 cm in width. The average weight of the Silk samples was 0.79 g, the average weight of the Polyester samples was 0.71 g, the average weight of the Nylon samples was 1.31 g, the average weight of the Cotton samples was 1.90 g, and the average weight of the Wool samples was 1.30 g. The weights and sizes are summarized in Table 1 and illustrated in Figure 1.

Table 1: Fabric sample dimensions and weights

Fabric Material	Dimensions (W×L)	Weight (g±S)
Silk (100%)	5 cm×20 cm	0.788 5 g (±0.026 5)
Polyester (100%)	5 cm×20 cm	0.713 8 g (±0.018 4)
Nylon (100%)	5 cm×20 cm	1.312 0 g (±0.218 2)
Cotton (100%)	5 cm×20 cm	1.893 3 g (± 0.272 0)
Wool (100%)	5 cm×20 cm	1.284 2 g (± 0.085 0)