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Impact of Sweat Absorption on the Electrostatic Potential Build-Up in Cotton and Nylon Fabric Samples

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Abstract

Natural and synthetic fibers can be significant sources of electrostatic build-up in garments. The intrinsic electrical properties of fibers are the result of their chemical composition and polymer structure. Factors such as moisture, temperature, and friction intensity can influence these properties. Due to the insulative characteristics of most fibers, fabrics keep their charge for relatively long periods. This can lead garments to cling to each other, attract dust particles, and create potential hazardous discharge shocks. Moisture increases the electrical conductivity of fibers that leads to a decrease in the build-up of electrostatic potential. The purpose of this study was to identify the impact of absorption of distilled water and electrolyte solution on fabric conductivity and subsequent electrostatic build-up. The study consisted of three components: 1, Comparison of the intrinsic electrical resistance of distilled water to electrolyte solution. 2, Assessment of the electrical resistance of cotton and Nylon fabric samples in relation to decreasing levels of fluid retention. 3, Determination of the electrostatic build-up in Cotton and Nylon fabric samples for dry and wet conditions. The results showed that cotton absorbed more distilled water and electrolyte solution than Nylon. However, the reduction in electrostatic build-up was similar for both. The results indicate that body sweat (electrolyte) can substantially reduce the electrical resistance characteristics of both natural and synthetic fibers and can substantially reduce the generation of electrostatic potential in garments.

Keywords: Sweat; electrolytes; electrical resistance; electrostatic potential; synthetic and natural fibers

1 Background

Natural and synthetic fibers can be significant sources of electrostatic build-up in garments. The intrinsic electrical properties of fibers are the result of their chemical composition and polymer structure. Factors such as moisture, temperature, and friction intensity can influence these properties [1]. Due to the insulative characteristics of most fibers, fabrics keep their charge for relatively long periods. This can lead garments to cling to each other, attract dust particles, and

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create potential hazardous discharge shocks [2, 3]. Moisture increases the electrical conductivity of fibers that leads to a decrease the build-up of electrostatic potential. The purpose of this study was to identify the impact of absorbing distilled water and electrolyte solution (human sweat) on fabric conductivity and subsequent electrostatic build-up.

1.1 Electric Properties

Textile materials used in clothing are generally poor conductors of electricity. Under static conditions, the atoms within a material are neutral as negatively charged electrons are being balanced by the positively charged protons. However, when one of the atoms encounters another atom through friction, electrons are attracted to the nucleus of the other atom. Some of the electrons may be removed altogether through this friction. The material that loses the electrons then becomes positively charged while the other garment layers will develop an opposite charge as they rub against each other. When the layers are separated, one will retain its positive charge and the other a negative charge. This separation of electrons and protons results in static cling. Charged clothing can induce an electrostatic charge on the entire human body. However, moisture absorbed by the fabric can significantly increase the conductivity of the fabric and reduce the build-up of electrostatic potential [4].

1.2 Moisture

Sweating is a major source of liquid absorbed by fabrics. The amount of sweat created inside a garment is related to the thermal insulation imposed by a garment, the external environmental temperature and the physical work performed by a person. Studies have addressed the relationship between moisture absorption in textiles and changes in their electrical properties. Fabrics made of different fiber materials have been shown to exhibit different values of electrical resistance. The electrical resistance of fabric samples has been shown to be inversely related to the moisture content in the fabric and the electrical resistance of fabric samples has been shown to be linearly related to the testing distance and exponentially related to the electrolyte concentration [5, 7].

1.3 Triboelectric Charging

The electrostatic charge created by friction between two materials is called "triboelectric charging". The amount of charge created by the triboelectric effect depends on the area of contact between two materials, the moisture in the material, the water vapor pressure in the air, the molecular structure of the materials, the friction intensity imposed on the two materials, and other factors [6, 8, 9]. Once a charge is created, it becomes an electrostatically charged material. This charge may be transferred to another material resulting in an electrostatic discharge event. Moisture increases the electrical conductivity of the fibers and can decrease the build-up of electrostatic potential. Fluids containing ions such as body sweat can increase the electrical conductivity of fabrics while fluids with fewer ions such as distilled water do not increase electrical conductivity as much.

Virtually all materials can be triboelectrically charged. How much charge is being generated, where that charge goes, and how quickly, depends on a material's physical, chemical, and electrical conductive characteristics.