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Application of Silk Templated Electronic Yarns in Multifunctional Textiles and their Design and Fabrication

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Abstract

For e-textile applications, conductive silk fibers (CSFs) are constructed with carbon nanotubes and silk fiber. We incorporate the complementary advantages of both components into a single hybrid fiber system by employing a scalable dip-coating strategy. Silk fibers provide mechanical toughness and strength, and carbon nanotubes provide functions like water resistance, solvent resistance, and thermal and electrical conductivity in such a system. CSFs can be woven into electronic textiles using automated fabric machines due to their mechanical and functional advantages. The resulting e-textiles can withstand washing with high-intensity or automated ultrasonics. These CSF e-textiles have potential applications in wearable devices, human augmentation, healthcare monitoring, and human-machine interfaces. They can be used as wearable sensing platforms to detect and monitor surrounding physical and chemical signals like force, temperature, and solvents.

E-textiles are interesting in a lot of different areas, like real-time healthcare monitoring and wearable electronics. Techniques for designing and fabricating e-textiles to meet the various requirements remain significant obstacles. Natural silk fibers, an ancient and unparalleled textile fiber, may be considered as a solution to these problems. However, natural silks that conduct electricity have not yet been produced due to processing difficulties. In this paper, we present a method for making conductive silk fibers (CSFs) using a scalable dip coating. A custom-made carbon nanotube (CNT) paint was used to functionalize natural silk fibers. This paint selectively scratches the surface of the silk fibers without destroying the fibers' internal structure. The CSFs maintained the mechanical performance, super hydrophobicity, solvent resistance, and thermal sensitivity of the silks and CNTs. The CSFs can be consequently woven into textures, bringing about materials delicate to encompassing actual boosts, including force, strain, temperature, and solvents.

Keywords: Chemical signals • Silk fibers • Human machine interfaces

Introduction

Fabrics with integrated electronic components, such as batteries, sensors, circuits, lights, displays, and even tiny computers, are referred to as smart textiles (also known as e-textiles). For real-time healthcare monitoring, motion sensing, portable communication, and human augmentation applications, such systems offer intelligent and wearable materials. E-textiles must not only meet the basic requirements of clothing comfort, light weight, heat retention, air permeability, and good durability but also provide additional value to the wearer because they are smart, wearable systems. E-textiles, for instance, are expected to monitor and regulate body temperature while also providing wind resistance, protecting against extreme environmental dangers like drenching rain, solvent erosion, or radiation damage [1].

Discussion

E-textiles frequently require electrical conductivity in addition to fibers that can be woven into a textile context. Conducting or semi-conducting materials that are widely used are based on metallic threads. These materials are typically rigid, brittle, and expensive, making it difficult to use them in fabrics that are lightweight and can withstand large deformations. As a result, conducting nanomaterials like carbon nanotubes (CNTs) and graphene are being used in the creation of stretchable and electronic polymer/carbon-based fibers. Notwithstanding, it stays testing to consolidate handling, mechanical, electrical, and underlying benefits in a solitary fiber framework For example, poly(3,4-ethylenedioxythiophene)- poly based conductive filaments include high conductivity yet their mechanical execution stays unfit to meet the necessities of programmed material assembling. Silks, on the other hand, are ancient textile fibers with distinctive properties suitable for smart textile applications. Particularly, silks have a mechanical toughness that is several times higher than that of Kevlar fibers and metallic and carbonic threads. Silks also have the advantages of being light, inexpensive, sustainable, long-lasting, biocompatible, and produced in large quantities. Silks, on the other hand, are hampered in e-textile applications due to their insulating properties in contrast to the necessary conductive characteristics of e-textiles. Wet-spinning, dry-spinning, or feeding silkworms and spiders with carbon nanomaterials are some of the methods that researchers have developed to introduce conductive components (such as metal particles, graphene, or CNTs) into silks in order to produce conductive silk fibers [2].

Conclusion

However, these hybrid fibers typically lack sufficient conductive components to achieve conductive percolation thresholds. Another effective method for making conductive textiles is to carbonize silk fabrics; however, high-temperature processing destroys the mechanical strength and toughness of natural silks. As a result, meeting the requirements for e-textiles necessitates developing CSFs with superior mechanical and conducting properties. In this study, we developed a low-cost and scalable method for using CNTs to dissolve and alter the surface of natural silks. To adhere to natural silk fibers that had been degummed, HFIP-stabilized CNT paint was developed. Because HFIP can be used to controllably etch the silk fiber surface, a strong bond was established between the CNT paint and the surface of the silk fiber. Silk

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fibers are coated uniformly with CNTs, which provide an electrically conducting path and, consequently, a self-sensing mechanism for the CSF structure's response to various physical stimuli. At long last, we integrate yarn-turning and programmed winding around procedures to manufacture e-materials. These CSF-based e-materials coordinate the benefits of both the silk filaments and the CNTs, with aversion to the body and natural improvements like power, strain, temperature, and solvents. Wearable devices, human augmentation, healthcare monitoring, and human-machine interfaces could all benefit from such systems [3-5].

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Conflict of Interest

None.

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