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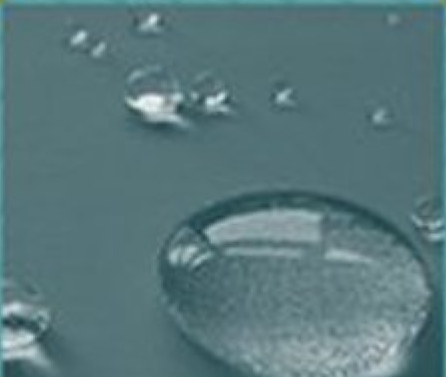

Biologically inspired textiles

Edited by A. Abbott and M. Ellison

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Biologically inspired textiles

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Historically, The Textile Institute has published books of interest to its members and the textile industry. To maintain this policy, the Institute has entered into partnership with Woodhead Publishing Limited to ensure that Institute members and the textile industry continue to have access to high-calibre titles on textile science and technology.

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Introduction

Textiles have one of the longest histories of all human activities. Beginning with prehistoric humans who fashioned clothing with available biological materials, such as animal skins and furs, the industry evolved to the eventual use of plant stalk derived fibers and seed hairs (flax and cotton). Depending on the geographic location, animal skins such as those from wolves, bears, deer, moose, and leopard were used as prized garment materials. In Chapter 8, the use of biomimetic principles applied to the structure and properties of animal furs in the fashioning of synthetic alternative textiles is discussed.

The use of animal skins did not require development of technology for conversion of fiber materials to fabrics; eventually, methods for construction of yarns from fiber were developed, and this led on to methods of basket weaving and conversion of yarns into fabrics. Concomitant with the rise in animal husbandry, significant amounts of animal hairs could be harvested from sheep (wool), goat, camel, and even rabbit and used as the feedstock for yarn and fabric. Similarly, with the increase in cultivation of plants, agrarian societies could produce substantial amounts of plant fibers to be used in textile manufacture. Thus, the fibers in the stalks of plants, leading to ramie, jute and hemp fibers, and seed hair of the cotton plant (perhaps viewed as advanced materials during that era) were relatively quickly incorporated into textiles.

An event that heralded one of the major advances of the new age of textile fibers, and which foreshadowed the work presented here in the opening chapters of this book, occurred in the mid-nineteenth century with the discovery of the solubility of nitrocellulose in simple solvents (e.g. acetone) allowing the production of synthetically derived fibers. Unfortunately, nitrocellulose, also known as guncotton, is highly flammable, so the commercial viability of these fibers was limited. Nonetheless, this concept illustrated that humankind was no longer strictly limited to the use of naturally produced material but was capable of producing novel fibers not present in nature. By the late nineteenth century, the method for production of cuprammonium rayon was discovered. This fiber, made from cellulose, was touted as being the manmade replacement for silk. During this same era, many other methods for converting cellulose from many natural sources were developed.

Another seminal event on the road to synthetic fiber production was the discovery by Carothers of the method for making nylon in the early twentieth century. This fiber is a truly synthetic material, in that the starting materials are not found in nature, albeit derived from petroleum. This discovery, and many more, was the genesis of the synthetic materials industry. As it relates to the current generation of synthetic materials, the power of human ingenuity evidenced by these developments in fibers is enormous.

Throughout this period many synthetic processes were investigated to replace natural silk production. Produced by silk moth caterpillars, and harvested through a labor-intensive process, silk was quite expensive; hence, it was deemed desirable to find a substitute process yielding a high value-added product of similar or higher quality. From the earliest guncotton fibers to present-day versions of regenerated cellulose, this quest has been followed, with varying degrees of success. Along the way, the lessons learned provided much insight into improving our capabilities for designing and producing novel materials with desired properties.

Design principles for clothing and for other applications of fiber-based textile materials are represented in several chapters in this work. In Chapter 6, Kapsali presents the use of biomimetic principles in the design of clothing. It should be noted, however, that, in today's world, textiles are not just about human clothing. Development of technical textile materials founded on biological principles is the subject of the two chapters (7 and 10) by Stegmaier in which self-cleaning materials, energy harvesting, and novel filtration materials, and others, are discussed.

There are many other applications of textiles such as composite reinforcement materials. Inspiration taken from biology for enhancement of these materials is discussed in Chapter 5 by Santulli. Although this is a relatively modern area, the use of clay-based composites in construction notwithstanding, this chapter brings the use of natural, sustainable (plant) fibers to the fore.

One of the main themes in this book is the use of molecular biology techniques for the production of fibrous materials. Chapters on these techniques form the genesis of the book. The scope and power of genetic engineering is the subject of much research, and the use of these techniques for fiber production will lead to as powerful a shift in our thinking as the early synthetic chemistry breakthroughs. In essence, the world of recombinant DNA technology has enabled us to refocus our attention on natural materials but through a distinctly new lens. In this book, we explore, via several contributions, the arena of biomaterials and the use of genetic engineering technologies as production systems to allow us not only to recreate extant materials but to create novel materials with new unexplored properties.

To realize the dream of producing designer materials from the products of simple living recombinant systems we need to understand the structure/function properties of the constituent natural ingredients of biomaterials (e.g. proteins and carbohydrates) and how natural systems process and produce biomaterials from these substrates. Thus, we present chapters on the examination of natural production systems for fibrous proteins and research into the processing steps involved in assembly of natural protein fibers. Further chapters deal with structural protein gene mimicry and production of recombinant proteins in simple microbial systems, and plant and animal systems.

This volume tells the complete story so far of biomimetics in textile manufacturing, leaving us with very exciting prospects for the manufacture of the next generation of novel textile materials for diverse applications using environmentally friendly technologies.