COATED TEXTILES

Principles and Applications

A. K. Sen, M.Tech, Ph.D.
Emeritus Scientist
Defence Materials and Stores Research and Development Establishment (DMSRDE)
Kanpur, India

TECHNICAL EDITOR
John Damewood, Ph.D.
Reeves Brothers, Inc.

TECHNOMIC
PUBLISHING CO., INC.
LANCASTER•BASEL

Coated Textiles

a**TECHNOMIC**®publication

Technomic Publishing Company, Inc.
851 New Holland Avenue, Box 3535
Lancaster, Pennsylvania 17604 U.S.A.

Sponsored by Department of Science and Technology, Government of India

Printed in the United States of America
10 9 8 7 6 5 4 3 2 1

Main entry under title:
Coated Textiles: Principles and Applications

A Technomic Publishing Company book
Bibliography: p.
Includes index p. 225

Library of Congress Catalog Card No. 2001088345
ISBN No. 1-58716-023-4

Table of Contents

Preface

COATED textiles applications are found in defense, transportation, healthcare, architecture, space, sports, environmental pollution control, and many other diverse end-product uses. I developed an insight into the breadth of the subject during my long association with the Defense Materials and Stores Research and Development Establishment (DMSRDE, Kanpur, India) while working on the development of protective clothing and related equipment. The opportunity to visit and work at several coating facilities has given me a feel for the complexity of the coated textile industry. The world production of coated fabrics used for defense alone every year is on the order of several billion dollars. Extensive research is being done on a global basis, and many new products, such as breathable fabrics, thermochromic fabrics, and charcoal fabrics, are entering the market. The subject is spread over a wide range of literature in polymer science and textile technology, with no single comprehensive book available. The motivation to write this book was to fill this void and to create a general awareness of the subject. This book is meant for scientists and technologists in academic institutions as well as in the coating and textile industry. The purpose of this book would be served if it could create additional interest in the coated textile industry and stimulate R&D activity to develop newer and better coated textile products.

A.K. Sen
Kanpur
2001

Acknowledgements

I had a long tenure with Defense Materials and Stores Research and Development Establishment (DMSRDE), Kanpur, India, as a research scientist, which has recently ended. DMSRDE, Kanpur, is a premier research establishment under the Defense Research and Development Organization (DRDO), Government of India, and is primarily responsible for research and development in nonmetallic materials required for the defense forces. The scope of R&D activity of the establishment encompasses a wide range of scientific disciplines including polymers, composites, organometallics, lubricants, anticorrosion processes, biodegradation studies, textiles and clothing, tentage, and light engineering equipment. It is one of the best equipped laboratories with various sophisticated analytical instruments.

The Department of Science and Technology (DST), Government of India, granted me a project to write a book on "Coated Textiles and their Applications." I am grateful to DST for this opportunity. I am also grateful to Professor G. N. Mathur, Director, DMSRDE, for permitting me to continue as Emeritus Scientist and for providing me access to a library and other facilities. His encouragement and help have been a source of inspiration. I am particularly thankful to my colleague Mr. N. Kasturia who first suggested that I write a book on the subject and for the help rendered at different stages in writing the book. I am indebted to Drs. V. S. Tripathi, L. D. Kandpal, Messrs. Anil Agrawal, T. D. Verma, Dhannu Lal, Darshan Lal, R. Indushekhar, G. L. Kureel, Miss Subhalakshmi, and several other colleagues at DMSRDE for their spontaneous help, suggestions, and input on specialized subjects. I also wish to acknowledge useful discussions and literature provided by Mr. A. K. Mody, Entremonde Polycoaters, Mumbai; Mr. M. L. Bahrani, Southern Group of Industries, Chennai; Mr. A. Narain, Swastik Rubbers, Pune; Mr. M. K. Bardhan, Director, SASMIRA, Mumbai; Professor P. Bajaj, I.I.T., Delhi; and Professor A. Nishkam, Principal, GCTI, Kanpur. Above all, I am thankful for the encouragement, inspiration, and valuable suggestions given by my wife, Sutapa.

Introduction

THE use of coated textiles for protective clothing, shelters, covers, liquid containers, etc., dates back to antiquity. Historically, the earliest recorded use of a coated textile was by the natives of Central and South America, who applied latex to a fabric to render it waterproof. Other materials such as tar, rosin, and wax emulsions have been used over the years to prepare water-resistant fabrics. Due to their vastly superior properties, rubber and other polymeric materials have become the preferred coatings. Today, coated fabrics are essentially polymer-coated textiles. Advances in polymer and textile technologies have led to phenomenal growth in the application of coated fabrics for many diverse end uses. Coated fabrics find an important place among technical textiles and are one of the most important technological processes in modern industry.

Textiles are made impermeable to fluids by two processes, coating and laminating. Coating is the process of applying a viscous liquid (fluid) or formulated compound on a textile substrate. Lamination consists of bonding a preprepared polymer film or membrane with one or more textile substrates using adhesives, heat, or pressure. Fibrous materials are also used for reinforcing polymeric materials to form composites for use in tires, conveyor belts, hoses, etc. The scope of this book has been restricted to coated and laminated textiles and does not address polymer fiber composites.

Several methods of production are used to manufacture a wide range of coated or laminated fabrics. Broadly, they are spread coating, dip coating, melt coating, and lamination. They not only differ in the processing equipment used, but also in the form of polymeric materials used. Thus, paste or solutions are required for spread coating; solutions are required for dip coating; and solid polymers such as powders, granules, and films are required for melt coating and lamination. The basic stages involved in these processes include feeding the textile material from rolls under tension to a coating or laminating zone, passing the coated fabric through an oven to volatilize the solvents and cure/gel the coating, cooling the fabric, and subsequently winding it up into rolls.

The properties of a coated fabric depend on the type of polymer used and its formulation, the nature of the textile substrate, and the coating method employed. The subject of coated textiles is thus interdisciplinary, requiring knowledge of polymer science, textile technology, and chemical engineering. The organization of this book is based on these considerations.

Among the various polymers used for coating and laminating, three classes are mainly used for coating: rubber, polyvinyl chloride, and polyurethane. These polymeric materials are specifically formulated with additives and compounded into a paste suitable for coating. The production of a polymeric coating fluid is one of the most important functions of the coating industry. The chemistry of these polymers, the additives used, and their processing for coating compounds and fluids have been described in Chapter 1. Conventional solvent coatings are losing favor, as they lead to environmental pollution. Several alternative processes, such as the ecofriendly aqueous polyurethane and radiation-cured coatings, are included in this chapter. The various adhesive treatments for improved elastomer-textile bonding have also been discussed in Chapter 1.

For many years, cotton was the primary fabric used for coating; however, today's coating industry uses diverse substrates made of rayon, nylon, polyester, polyester-cotton blends, and glass fibers that may be produced in woven, knitted, or nonwoven constructions. The physical properties of a coated fabric are affected by the nature of the fiber and the construction of the textile substrate. The choice of the substrate depends on the application of the material. Chapter 2 discusses the different fibers and their conversion into textile materials of various constructions used in the coating industry. The coating methods employed by the industry are discussed in Chapter 3. Emphasis is placed primarily on the principles, rather than on the engineering aspects, of the machinery. Chapter 4 describes the changes that occur in the physical properties of a fabric when it is coated. A brief account of rheological factors affecting the coating has been presented in Chapter 5. Thus, the raw materials, the coating methods, and the properties of the end product are presented in chronological sequence.

The large, ever-increasing variety of applications of coated fabrics is covered in the three subsequent chapters. Protective clothing for foul weather is one of the major applications of coated fabrics. In the last two decades, particularly after the development of GORE-TEX® laminates, there has been an explosion of development in breathable fabrics. Chapter 6 discusses all types of coated fabrics for foul weather protection with special emphasis on the developments in the field of breathable fabrics. Coated textiles used in synthetic leather, upholstery fabrics, fabrics for fluid containers, backcoating of carpets, and architectural textiles are discussed in Chapter 7.

In various applications of coated fabrics, a functional material such as dye, pigment, or carbon is applied on the textile materials with polymeric binders. These fabrics are being used as camouflage nets, thermochromic fabrics,

protective clothing for toxic chemicals, etc. This specialized category of coated fabrics is included in Chapter 8. Metal coatings are finding newer uses in EMI-RFI shielding and radar responsive fabrics. These fabrics are also discussed in this chapter.

The test methods pertaining to coated fabrics have been discussed in Chapter 9. The references are given at the end of each chapter. Properties of common polymers used for coating are separately provided in Appendix 1, and a few typical formulations are given in Appendix 2.