PDL HANDBOOK SERIES

Plastics Design Library

# Handbook of Adhesives and Surface Preparation

Technology, Applications and Manufacturing

Edited by
Sina Ebnesajjad

ELSEVIER

# HANDBOOK OF ADHESIVES AND SURFACE PREPARATION

## Technology, Applications and Manufacturing

Edited by

Sina Ebnesajjad

*President, FluoroConsultants Group, LLC*



ELSEVIER

Amsterdam • Boston • Heidelberg • London • New York • Oxford
Paris • San Diego • San Francisco • Singapore • Sydney • Tokyo

William Andrew is an imprint of Elsevier

William Andrew is an imprint of Elsevier
The Boulevard, Langford Lane, Kidlington, Oxford, OX5 1GB, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA

First published 2011



Material in this work originally appeared in *Adhesives Technology Handbook* (Second Edition), edited by Sina Ebnesajjad (Elsevier Inc., 2008, ISBN 978-0-8155-1533-3), *Surface Treatment of Materials for Adhesion Bonding*, edited by Sina Ebnesajjad and Cyrus F. Ebnesajjad (Elsevier Inc., 2006, ISBN 978-0-8155-1523-4), *Handbook of Adhesives and Sealants, Volume 1*, edited by Philippe Cognard (Elsevier Ltd, 2005, ISBN 978-0-0804-4554-0), *Handbook of Adhesives and Sealants, Volume 2*, edited by Philippe Cognard (Elsevier Ltd, 2006, ISBN 978-0-0804-4708-7) and *Applied Plastics Engineering Handbook*, edited by Myer Kutz (Elsevier Inc., 2011, ISBN 978-1-4377-3514-7).



**Notices**
Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

**British Library Cataloguing in Publication Data**
A catalogue record for this book is available from the British Library

**Library of Congress Control Number:** 2010937577

ISBN: 978-1-4377-4461-3



Printed and bound in the USA

11 13 12 11 10 9 8 7 6 5 4 3 2 1

# HANDBOOK OF ADHESIVES AND SURFACE PREPARATION


PLASTICS DESIGN LIBRARY (PDL)

PDL HANDBOOK SERIES

**Series Editor:** Sina Ebnesajjad, PhD
President, FluoroConsultants Group, LLC
Chadds Ford, PA, USA
www.FluoroConsultants.com

The **PDL Handbook Series** is aimed at a wide range of engineers and other professionals working in the plastics industry, and related sectors using plastics and adhesives.
PDL is a series of data books, reference works and practical guides covering plastics engineering, applications, processing, and manufacturing, and applied aspects of polymer science, elastomers and adhesives.

**Recent titles in the series**

Sastri, *Plastics in Medical Devices*
ISBN: 9780815520276

McKeen, *Fatigue and Tribological Properties of Plastics and Elastomers*, Second Edition
ISBN: 9780080964508

Wagner, *Multilayer Flexible Packaging*
ISBN: 9780815520214

Chandrasekaran, *Rubber Seals for Fluid and Hydraulic Systems*
ISBN: 9780815520757

Tolinski, *Additives for Polyolefins*
ISBN: 9780815520511

McKeen, *The Effect of Creep and Other Time Related Factors on Plastics and Elastomers*, Second Edition
ISBN: 9780815515852

To submit a new book proposal for the series, please contact
Sina Ebnesajjad, Series Editor
sina@FluoroConsultants.com
or
Matthew Deans, Senior Publisher
m.deans@elsevier.com

# Acknowledgments

In this work I have selected a range of material from recent books published by Elsevier, including titles in the William Andrew imprint. Thus, I would like to offer my recognition to the authors of the selected material, and editors of the books from which I have sourced this material: John Bishopp, Christian Decker, Cyrus F. Ebnesajjad, Guy Rabilloud, Peter G. Pape, Philippe Cognard, editor of the *Handbook of Adhesives and Sealants* and Myer Kutz, editor of the *Applied Plastics Engineering Handbook.*

I would like to offer my deepest appreciations to Dr. Kayvon Modjarrad (MD, PhD), Infectious Disease Specialist and Dr. Peter E. Dross, neuroradiologist for the review and revision of Chapter 14. Their patience in explaining medical topics to me was beyond generous. My thanks go to Dr. Norman Rocheleau, DDM for the review of the sections on dental applications of adhesives.

My sincere appreciation goes to my colleague, manager and friend Mr. Matthew Deans for his tireless support, knowledge, good nature, and patience. His support of this project has been essential to the materialization of the book.

I would like to thank my editorial assistant Miss Kristin N. Dross for her work on the contents of this book. She reviewed, edited and corrected the writings of the content, raised questions, and helped me find answers to them.

Lisa Jones was the project manager for the production of this book and has my heartfelt appreciation for her diligence and unlimited patience.

I wish to thank all the companies that have generously contributed to this book by allowing the author use of their data, information, illustrations, photographs and product and process. I have done my best to ensure the name of each company is cited for each use.

**Sina Ebnesajjad**
Chadds Ford, Pennsylvania

Dedicated to the memories of my dear friend
**William Andrew Woishnis**
Who left the world too early, too young.

# Preface

A basic industrial process is the bonding of similar and dissimilar materials to each other. Bonding using an adhesive has proven to be an effective means of attaching materials together.

There are numerous books about adhesives. Several excellent books are available that deal with the subject of adhesives from various viewpoints. Some have looked at adhesives from the perspective of synthesis, chemistry, or bonding techniques. Others have treated the subject from a practical standpoint. Of these, most are attempts to describe adhesion in relation to a variety of materials, including plastics, metals, wood, and so on. A few books regarding applications of adhesives are highly specialized in particular industries, such as metals and construction.

What is different about this book? The present book is focused on practitioners of adhesion technology from an end-user's perspective, thus covering most substrates, such as plastics, metals, elastomers, and ceramics. The information is aimed at allowing readers to select the right adhesive and successfully bond materials together. Other than the choice of the appropriate adhesive, surfaces must be pretreated according to specific methods and prior to the application of adhesives. By including generous selections from the recent back catalog of both Elsevier and William Andrew publishing (now part of Elsevier), I aim to provide to an audience of engineers and other professionals working with adhesives, a wide-ranging and practical handbook.

This book describes treatment methods that must be applied to a material surface before successful adhesive bonding is possible. There are numerous examples, ranging from wallpaper in a house and paint on surfaces to parts used in the construction of aircraft. The aim of the contents is to explain, in an accessible yet complete manner, all that is required to achieve successful adhesion bonding of different materials.

Fundamental material considerations have been given priority to facilitate the use of the contents of this book in different industries. The book is both a reference and a source for learning the basics. Additionally, it is useful for all involved in the product value chains, and it offers information helpful to engineers, chemists, students, and all others involved in material adhesion and processing.

Every attempt has been made to enhance the accessibility of the information to create a reader-friendly text. In the balance of practical and theoretical subjects, practical has been given definite precedence. This is a trade-off that the author readily acknowledges. There are numerous good books and sources for the study of the theory and science of adhesion and adhesives.

The references listed at the end of each chapter serve as both bibliography and additional reading sources. Most of the basic practical technology of adhesives was developed decades ago. Older references have been retained wherever they represent the preferred source of information for a specific topic. Readers can find a wealth of information and reports that have been declassified by the Defense Technical Information Center (www.dtic.mil), most of which date to the 1960s.

The book consists of four parts. Part I contains two introductory chapters that describe the fundamental concepts of surface treatment and adhesion. Part II is comprised of chapters that describe surface tension (energy) concepts, surface characterization techniques, and surface preparation methods for metals and thermoplastics, thermosets, and elastomers.

Part III describes the characteristics of adhesives from the standpoints of chemical structure and application. Heat-resistant and UV-cure adhesives are discussed in separate chapters because of their importance to the adhesive industry.

Part IV of the book describes the applications of adhesives with respect to special adherends. Applications of adhesives in aerospace, electronic, and medical/dental have been described in separate chapters because of the importance and breadth of adhesion use in these industries. There are few, if any, adhesives that are not used by these industries, thus rendering the information in the chapters useful to nearly any other

industry. After all, the aerospace industry has been a pioneer in the use of structural adhesive bonding in critical applications.

Appendix A discusses Safety, Environmental, Economic Aspects, and Future Trends. Appendix B provides an exact copy of the FDA Guidance for Tissue Adhesive for the Topical Approximation of Skin issued in May 2008. A glossary section rounds off the book.

I hope this book is useful to those who practice the art of adhesion as a profession. None of the views or information presented in this book reflect the opinions of any of the companies or individuals that have contributed to the book. If there are errors, they are an inadvertent oversight on the part of the author. A note indicating suggestions or specific errors to the publisher, for the purpose of correcting future editions, would be much appreciated.

**Sina Ebnesajjad**
Chadds Ford, Pennsylvania

# Contents