

CONSERVATION OF PLASTICS

materials science, degradation
and preservation

Yvonne Shashoua



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E2008001667



AMSTERDAM • BOSTON • HEIDELBERG • LONDON • NEW YORK • OXFORD
PARIS • SAN DIEGO • SAN FRANCISCO • SINGAPORE • SYDNEY • TOKYO
Butterworth Heinemann is an imprint of Elsevier



Butterworth-Heinemann is an imprint of Elsevier
Linacre House, Jordan Hill, Oxford OX2 8DP, UK
30 Corporate Drive, Suite 400, Burlington, MA 01803, USA

First edition 2008

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British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Library of Congress Cataloging in Publication Data

A catalog record for this book is available from the Library of Congress

ISBN: 978-0-7506-6495-0

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Typeset by Charon Tec Ltd., A Macmillan Company. (www.macmillansolutions.com)

Printed and bound in Slovenia

08 09 10 11 12 10 9 8 7 6 5 4 3 2 1

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Conservation of Plastics

*This book is dedicated to the memory of my much-loved,
Maureen Shashoua, who was fascinated by plastic jewellery and
designs and inspired me greatly.*

FOREWORD

Plastics are the materials of today. It is hard to imagine a modern-day product that does not use plastics. In countless cases, products which we take for granted could not have been developed without plastics. From toothbrushes to telephones, from computers to cars, from electrical appliances to aeroplanes, plastics are the wonder materials of this modern age. Increasing amounts of plastics are also being produced and used by artists. Plastics are thus making our lives comfortable, enjoyable and safe.

The need for knowledge about the conservation of plastics in cultural heritage is thus becoming increasingly important. Although a very substantial body of literature exists on the chemical, technological and manufacturing aspects of plastics, the scope of such books is too broad for conservation needs. Moreover, they often go into far too much depth to be directly useful for conservation purposes. On the other hand, the books which have been published until now about plastics conservation deal only with one or two plastic materials, and thus do not provide a total overview.

The first time I wished for a book like *Conservation of Plastics* was in 1990 when I started doing research on the conservation of cultural heritage plastics. At that time conservators could only use the introduction sections on modern materials conservation from conference proceedings published in the late 1980s and early 1990s as references. In 1993 *Saving the Twentieth Century* was published. It comprised the postprints of the conference of the same title held in 1991. *Saving the Twentieth Century* described exactly the problems which I encountered during my first years in plastics research. In 1997 the conference postprints *Modern art, who cares?* was published, providing good insight into the problems of modern art conservation. However, more information about plastics materials was needed.

There has long been a strong need felt by the conservation community for a book that provides a complete understanding of plastics degradation and conservation and that covers the latest advances in technology. This publication, *Conservation of Plastics*, is exactly what the field needs. It fills the gap between books describing the chemistry and technology of plastics on the one hand, and the traditional conservation literature on the other. Moreover, it facilitates the understanding of the relationships between the chemical and physical

background of plastics, degradation processes, conservation treatments, and the behaviour of objects during those treatments. With its broad scope, it is likely to benefit collectors, conservators, curators, conservation scientists, and anyone with interest or responsibility for the care of plastics.

The Conservation of Plastics provides important information on the definition of plastics, their history, technology, properties, identification, degradation, conservation and future preservation. Most importantly, it describes the state of the art of one of the newest fields in cultural heritage – plastics conservation. The information in this book is placed in context, and is illustrated with many examples that those involved in decision-making processes for conserving plastics objects will find helpful. This book will be present on every conservation table, in all museums, training schools and universities, where it will be used on a daily basis. The beneficiaries will be the objects themselves: plastics for everyday use, designer objects, furniture, toys and, most of all, modern and contemporary art.

The author has made a tremendous effort in preparing this book, focussing attention on both basic and advanced aspects. Yet, she has kept it simple and readable, making it an enjoyable read which will help any beginner and expert alike to understand plastics conservation. This book has been very thoughtfully divided into eight chapters, each of which has a logical sequence of sections. It includes the latest trends, where the emphasis has been laid on the future needs of plastics conservation. This book reflects the author's rich experience in more than 15 years of interdisciplinary and international activities in academia, industry and conservation science.

It is not often that one gets a chance to write a foreword to a book which has immense potential to become a standard handbook for the conservation of plastics in cultural heritage. I congratulate Yvonne Shashoua for this fine contribution, and am happy to recommend this pioneering book to all in the field.

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Former coordinator Modern Materials and
Contemporary Art Working Group ICOM-CC
Member of the board of ICOM-CC

PREFACE

Plastics have had a significant influence on industrial, domestic and cultural aspects of everyday life in the twentieth and twenty-first centuries. They represent advances in technology, illustrated by the dramatic growth in number and type of information storage media available since the 1970s, credit and payment cards, medical applications and food containers which can be taken directly from freezer to microwave oven to dinner table. The development of plastics reflects economic history. Restrictions on imported rubber latex, wool, silk and other natural materials to Europe during World War II stimulated the development of synthetic alternatives. Plastics may also be collected to study a society's attitudes towards new materials and technologies. Plastics are increasingly used to create artworks. In short, plastic's significance is reflected in the prophecy made by artists Marcel Biefer and Beat Zgraggen in 1991 which states that 'plastic artefacts will be the most important witnesses to our time'. While museums continue to acquire objects which reflect everyday life and historical events, the proportion of plastics in collections will increase.

Plastics have short lifetimes compared with those of traditional materials found in museums, exhibiting deterioration within 5 to 35 years of acquisition. Deterioration and conservation of plastics objects in museums has only been recognized formally as an area worthy of research since 1991. However, despite its novelty, the conservation of plastics is a rapidly developing field. A measure of the recognition of plastics conservation as a serious discipline was the creation of the working group 'Modern Materials and Contemporary Art' (MMCa WG) by the International Council of Museums Committee for Conservation in 1996.

Museums and other cultural institutions aim to conserve plastics for future generations and to preserve information about outdated materials and technologies. In addition to conserving the plastic material itself, preserving the design, concept or intention reflected by the object is often important. Private collectors wish to preserve the artistic, historical and financial values of their objects and artworks. With the dramatic increase in monetary value of modern art since 2000, art insurance companies are also concerned with the short useful lifetime of plastics.

The purpose of *Conservation of Plastics* is to distil the extensive knowledge produced by the polymer and plastics industries, designers, environmental and conservation professionals into a single publication focussing on the

preservation and conservation of plastics. The book focusses on three-dimensional objects constructed from semi-synthetic and synthetic plastics. The book progresses from the historical development of plastics, through production and the chemical and physical properties of the materials formed to identification and the factors causing physical, chemical and biological degradation. Tables of optical, physical and chemical properties of the most common plastics in collections, one for each material, are presented in Appendix 1 to assist both selection and identification of plastics. Photographs of flame tests used to identify plastics augment written descriptions. Terms used to define degradation are illustrated with photographs in Appendix 3. *Conservation of Plastics* describes and discusses critically the developments in techniques and materials used to conserve semi-synthetic and synthetic plastics and proposes tools to further develop this new discipline. Future directions for conservation of plastics are also proposed.

ACKNOWLEDGEMENTS

It would not have been possible for me to write this book without the support of my employer, the National Museum of Denmark. I was given a paid research year to review the literature and prepare the text, which expanded into 20 months. I am extremely grateful to Jesper Stub Johnsen, Head of Conservation at the National Museum of Denmark and Mads Christian Christensen, Head of the Research, Analysis and Consultancy section, who took an active interest in the book and were always positive about its progress. My colleagues in the Conservation Department, particularly Poul Jensen, Jens Glastrup and Martin Mortensen, have been generous with their time to discuss aspects of the text and have inspired and supported my work from start to finish. I am also grateful to Roberto Fortuna and Kira Kroeis Ursem, photographers in the Conservation Department, for their creativity, particularly in capturing images of burning plastics and librarian Pla Olsen for her effectiveness in obtaining references at short notice.

I received invaluable comments on all chapters from Brenda Keneghan, polymer scientist at the Victoria & Albert Museum and Louise Cone, conservator at the Danish National Gallery. Both gave up their free time, sometimes at short notice and always without complaint. The quality of the information and ideas contained in the book is higher for their experienced input. Anita Quye, conservation scientist at the National Museums of Scotland, and Thea van Oosten, senior researcher at the Netherlands Institute for Cultural Heritage, contributed greatly to the book at the planning stage. I have also learned much from the comments on style given by Tim Padfield, consultant in museum climate.

On a personal note, I wish to thank Jan K. Madsen, Ron, Neil and Michelle Shashoua for their constant patience, support and belief in my ability to complete this book.

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Appendix 3

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Plastics in collections

Summary

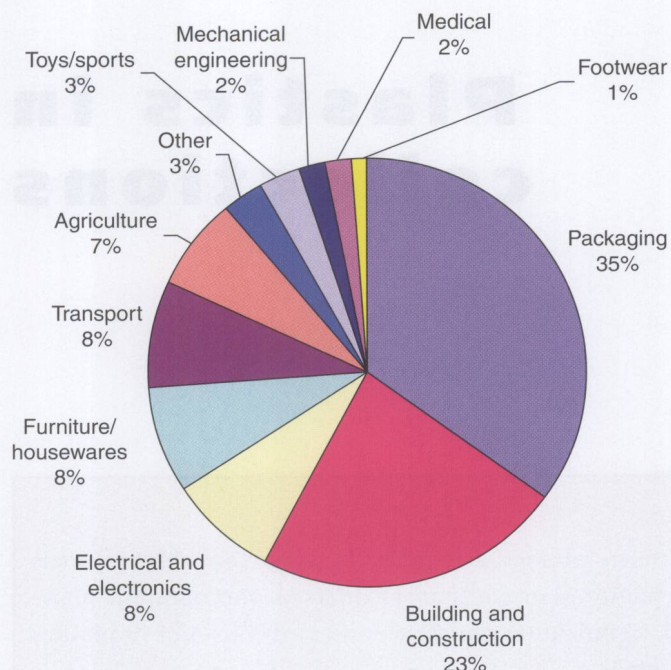
Chapter 1 defines the term 'plastics' as used in the book (only 3D materials will be addressed, not paintings or synthetic lacquers or photographic materials). The acquisition, significance, condition and current status of plastics conservation are discussed.

Plastics are semi-synthetic or synthetic materials which can be manipulated to form films, fibres, foams or three-dimensional objects. Natural polymers from plants, insects and animals are not discussed in this book. Synthetic paints, synthetic textiles and photographic film contain plastics but will not be discussed in this book because their conservation is the focus of specialist publications (Chiantore and Rava, 2005; Learner, 2005; Tímár-Balázs and Eastop, 1998; Lavedrine et al., 2003). Plastics are based on polymers, also known as macromolecules, which are large molecules made by joining together many smaller ones. The chemical and physical properties of liquid polymers are modified with additives and shaped to convert them into solids with dimensionally stable forms.

Increased numbers of processing and fabrication techniques have allowed modern plastics to be manipulated in thin film, bulk and foam forms, and to be combined and reinforced with fibres, metals, wood and other materials. Different plastics types can also be laminated together using heat. Today there are approximately 50 different basic types of polymer included in 60 000 plastics formulations. The world's annual consumption of plastic materials has increased from around 5 million tonnes in the 1950s to nearly 100 million tonnes in the year 2000. In 1982, plastics production surpassed that of steel worldwide and that year has been heralded as the start of the Plastic Age (Ward, 1997). Packaging is the biggest market sector for plastics worldwide (Figure 1.1). Polyethylene and poly (vinyl chloride) are the most highly consumed of all plastics worldwide (Brydson, 1999).

Figure 1.1

Applications of plastics worldwide (Morgan, 1994).



The rapid growth in plastic applications during the twentieth century may be attributed to the properties of plastics, which include:

- high versatility and ability to be tailored to specific technical needs
- little or no finishing, painting or polishing required
- lower density than competing materials, reducing fuel consumption during transportation
- excellent thermal and electrical insulation properties
- good safety and hygiene properties for food packaging.

Because the raw materials for plastics are based on crude oil, there is close correlation between their prices. Although plastics are generally considered to be low cost raw materials, at around £1500 per tonne, they compare poorly with their main competitors including steel at £250 per tonne, and aluminium and zinc at £1000 per tonne.

1.1 Collecting plastics

Museum objects are rarely collected for their material type alone but because of their origin, function, design, rarity, cultural, historical or artistic significance. Plastics are collected for the same reasons. Synthetic plastics have had a significant influence on industrial, domestic and cultural aspects of everyday life in the twentieth and twenty-first centuries. Their significance is reflected in

the prophecy by artists Marcel Biefer and Beat Zraggen in 1991 which states that 'plastic artefacts will be the most important witnesses to our time' (Biefer and Zraggen, 1991).

Plastics represent advances in technology, illustrated by the dramatic growth in the number and type of information storage media available since the 1970s, credit and payment cards and food containers which can be taken directly from freezer to microwave oven to dinner table without breaking. Before the 1940s, it was not possible to drink hot coffee from a plastic cup without it softening and becoming too hot to hold – an activity which is commonplace today. Plastics are also collected to show the social effects of technological development.

Industrial archaeology is a rapidly expanding, interdisciplinary method of studying material and immaterial evidence created for, or by, industrial processes from the beginning of the Industrial Revolution in the second half of the eighteenth century up to and including the present day. Traditionally, industrial heritage has concerned mines, steelworks and other heavy industries, but recent projects include the study of plastics. In addition to allowing the study of technical processes, collecting plastics provides associations with living conditions of the plastic workers, their health and level of education. In 1995, the Norwegian Museum of Science and Technology initiated a collaborative project known as 'Plastics in modern Norway'. Two of the project's goals are to show how the use of plastics affects artefacts and consumer culture in Norway today and to stimulate collaborative research and collection of contemporary history (Rossnes et al., 2002).

Plastics may also be collected to study a society's attitudes towards new materials and technologies. When the first man-made plastic, cellulose nitrate, was exhibited at the Great International Exhibition in England in 1862 by Alexander Parkes, it was designed to imitate luxury materials, such as tortoiseshell and ivory, which were in increasing demand and diminishing supply. However, the image of plastics as highly valued luxury goods faded when colourful, post-World War II designs were marketed in large numbers and at low cost. Plastics developed a long-lasting image as low value, poor quality and ephemeral pieces. It has even been said that dreaming about plastics suggests that one is fake and artificial! The 1980s saw a change in perception of plastics from disposable materials to fashionable, highly collectable pieces with historical and technological significance. In the twenty-first century, industrial plastics have gained a reputation as pollutants, both during use and on disposal, and as health hazards, particularly to young children. By contrast, art made from recycled plastics is highly collectable today.

The development of plastics reflects economic history. Restrictions on imported rubber latex, wool, silk and other natural materials to Europe during World War II stimulated the development of synthetic alternatives. Between 1935 and 1945, many new polymers were introduced including polyethylene, polyamides, poly (methyl methacrylate), polyurethanes, poly (vinyl chloride),