

# **THERMOSETTING POLYMERS**

**JEAN-PIERRE PASCAULT**  
**HENRY SAUTEREAU**

*Institut National des Sciences Appliquées  
Villeurbanne, France*

**JACQUES VERDU**

*Ecole Nationale Supérieure d'Arts et Métiers  
Paris, France*

**ROBERTO J. J. WILLIAMS**

*University of Mar del Plata and  
National Research Council (CONICET)  
Mar del Plata, Argentina*

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## Preface

The subject of thermosetting polymers receives very brief consideration in most books covering the fundamentals of polymer science. Usually the chemistry is represented by the structure of a phenolic network of the resol type, and some statistical calculations based on Flory's derivations are presented. Therefore, anyone trying to get a first approach to the subject finds only books with chapters written by different authors and aimed at specialists in the field.

The aim of this book is to present a unified coverage of the field of thermosetting polymers, written for readers who are making their first contact with this area. The analysis, however, is carried out to a derivation of concepts and equations useful for practical purposes. The book will be of value for undergraduate and graduate students as well as for people involved in R&D activities in the industrial sector. Some of the material has been used in undergraduate and graduate courses given at ENSAM (Paris), INSA (Lyon), and INTEMA (Mar del Plata, Argentina).

The scientific basis of different aspects of thermosetting polymers was well established in the 1980s and '90s. It was a period of great excitement for people working in the field (the Gordon Conferences were devoted to this subject; a Polymer Network Group was created; several symposia were organized by different research groups; and new, specific journals were launched). Most of the developments during this period are now well settled and constitute the heart of the book. Among the subjects that may be

considered firmly established are mean-field theories of network formation; transformation diagrams used to follow the evolution of the material along polymerization; the interpretation of experimental data obtained by differential scanning calorimetry; rheology and dielectrical spectroscopy; ways to synthesize rubber-modified thermosets and thermoplastic-thermoset blends; the influence of crosslinks on physical, elastic, and viscoelastic properties of polymer networks, and factors affecting the yielding and fracture of neat and modified thermosetting polymers. Subjects that are still controversial or less established, such as the inhomogeneity of some thermosetting polymers and aspects related to their durability, are also discussed in the book. Topics related to processing and to composite materials are analyzed only in the contexts of temperature and conversion profiles developed during the cure.

The core of research activities in the field has evolved to a more sophisticated level. The development of advanced materials based on thermosetting polymers is a very active field. It includes nano-structured materials, organic-inorganic hybrid materials, multicomponent blends, polymer-dispersed liquid crystals and networks with liquid crystalline behavior, and materials with a very low dielectric constant, etc. New analytical techniques are available such as microcalorimetry and atomic-force microscopy. Sophisticated computer simulations give a more realistic approach to modeling the build-up of the polymer network or following the evolution of temperature and conversion during the cure in a complex mold. Most of these subjects are outside the scope of this book. A list of selected references, suggested to complement and expand on the material presented in the book, is available at the end of many chapters.

This book is the result of almost two decades of scientific cooperation among the authors that resulted in a significant number of joint publications. In spite of the official grant codes, we always designated our joint research activities as the Asado (typical Argentine meat) – Beaujolais (typical French wine) Program. And some of the more fruitful discussions took place in the course of a Beaujolais tour or during the ritual of preparing the asado.

Over all these years we have learned much from discussions with many colleagues working in this field. The list would be so large—and the possibility of forgetting someone so great—that we prefer to present a general acknowledgment to many friends who contributed significantly to the ideas and concepts developed in this book.

*Jean-Pierre Pascault*  
*Henry Sautereau*  
*Jacques Verdu*  
*Roberto J. J. Williams*