139
Advances in Polymer Science

Springer
Berlin
Heidelberg
New York
Barcelona
Hong Kong
London
Milan
Paris
Singapore
Tokyo

Mineral Fillers in Thermoplastics I

Raw Materials and Processing

Volume Editor: J. Jancar

With contributions by
E. Fekete, P.R. Hornsby, J. Jancar,
B. Pukánszky, R.N. Rothon

Springer

This series presents critical reviews of the present and future trends in polymer and biopolymer science including chemistry, physical chemistry, physics and materials science. It is addressed to all scientists at universities and in industry who wish to keep abreast of advances in the topics covered.

As a rule, contributions are specially commissioned. The editors and publishers will, however, always be pleased to receive suggestions and supplementary information. Papers are accepted for „Advances in Polymer Science" in English.

In references Advances in Polymer Science is abbreviated Adv. Polym. Sci. and is cited as a journal.

Springer WWW home page: http://www.springer.de

ISSN 0065-3195
ISBN 3-540-64621-3
Springer-Verlag Berlin Heidelberg New York

Library of Congress Catalog Card Number 61642

Typesetting: Data conversion by MEDIO, Berlin
Cover: E. Kirchner, Heidelberg
SPIN: 10573681 02/3020 - 5 4 3 2 1 0 - Printed on acid-free paper

Volume Editor

Prof. Josef Jancar
School of Chemistry
Technical University Brno
Purkynova 118
61200 Brno
Czech Republic
E-mail: jancar@fch.vutbr.cz

Editorial Board

Preface

In recent years, a growing number of engineering applications of light-weight and energy efficient plastics can be found in high-quality parts vital to the functioning of entire equipments and structures. Improved mechanical properties, especially balance of stiffness and toughness, are among the most frequently desired features of the new materials. In addition, reduced flammability is considered the single most important requirement for further expansion of plastics into large volume and demanding markets such as construction and mass transport. Production of power cables also requires flame retardant cable jacketing plastics to replace or at least to reduce consumption of environmentally unsound PVC.

The two principal ways to achieve the goals mentioned above include the development of completely new thermoplastic polymers and various modifications of the existing ones. Development and commercialization of a new thermoplastic require mobilization of large human and financial resources, the latter being within the range from $100 million to $10 billion, in comparison to $100 thousand to $10 million needed to develop and commercialize polymeric material with prescribed end-use properties using physical or chemical modification of an existing plastic. In addition, the various markets utilizing thermoplastics demand large flexibility in material properties with only moderate volumes, at the best. Hence, while the majority of both commodity and engineering thermoplastics were introduced during the 18 years between 1954 and 1972, only PEEK and liquid crystalline polymers have reached the market in the last 20 years (Table 1). On the other hand, more than 4000 blends and compounds entered the marketplace between 1980 and 1997, while only very few in the years before [1].

From the arguments put forward above, one can draw the conclusion that the physical modification of the existing polymers, i.e. their compounding with solid fillers or blending with other polymers, has been the primary approach used in the development of polymeric materials „tailored“ for the majority of new engineering applications. Development and production of completely new thermoplastics with desired properties appear to be a long term, very expensive and risky alternative to the engineering of thermoplastic materials using compounding with fillers, elastomers and blending with other thermoplastics.

In addition to purely consumption related reasons, the trend towards extension of the product range by physical modifications of existing plastics is sup-

Table 1. Commercialization dates for selected thermoplastics used as matrices in compounding [1]

Year	Polymer	Producer	Abbreviation
1927	polyvinylchloride	B.F. Goodrich	PVC
1936	polyamide 6,6	DuPont	PA6,6
1938	polystyrene	Dow	PS
1939	low density polyethylene	ICI	LDPE
1954	polyurethanes	Bayer/DuPont	PUR
1954	high density polyethylene	Hoechst	HDPE
1954	polyethyleneterephthalate	ICI	PET
1956	polyamide 6	Allied	PA6
1957	polypropylene	Phillips Petroleum	PP
1958	polycarbonate	GEC/Bayer	PC
1959	linear low density polyethylene	DuPont	LLDPE
1965	polysulfone	Union Carbide/3M	PSO
1969	polybutyleneterephthalate	Celanese	PBT
1972	polyphenylene sulfide	Philips Petroleum	PPS

ported by the effort of the plastics industry to reduce the variety of produced thermoplastics and to supply the various markets with polymeric materials based on, in an ideal case, one polymer. In addition, this „unification" also appears reasonable for greatly improving ease of recycling, as it would lead to a reduction in the need for sorting of various plastics especially in recycling of cars and durable goods (refrigerators, computer cases, batteries, etc). Due to the large variety of plastics and rubbers used in current consumer and durable goods, recycling into reusable materials has been expensive with very little commercial success. Since the advent of metallocene catalyst technology, capable of producing polyolefins with properties ranging from elastomers to hard polymers in a single process, polypropylene has been among the most frequently cited candidates to fulfil this role.

Commodity thermoplastics (polypropylene, polyethylene, polyvinylchloride, etc.) and some engineering thermoplastics (nylons, PBT, etc.) have become attractive candidates for many engineering applications replacing traditional materials and substituting for more expensive resins [2]. Relatively low price, excellent chemical resistance, good processability, potential for part consolidation and assembly simplification due to part consolidation and the possibility of modifying mechanical properties in a wide range by adding fillers and elastomers has contributed to the growing application range of filled polyolefins, especially polypropylene (PP) and polyethylene (PE). This has been made possible by creating a solid database of experimental, theoretical and empirical knowledge gathered by researchers and compounders over the last 20 years. Part of the knowledge has been published, part remains with the companies as a portion of their „know-how".

This book aims to assemble this somewhat fragmented information, which is dispersed in a large body of literature, in a unified, coherent manner emphasizing both quantitative and qualitative relationships between structural variables and mechanical properties. The book is divided into two volumes, the first of which deals with raw materials and compounding technology. The second volume focuses on the relationships between structural variables and mechanical and physicochemical properties of particulate-filled thermoplastics. This volume deals with the current state-of-the-art in thermoplastic matrices, particulate fillers, surface modifications of fillers and with compounding and processing technologies. Despite the fact that this volume has been edited from contributions by scientists from three countries, effort has been devoted to orchestrate the individual contributions in a manner equal to monographs written by a single author.

Brno, July 1998 Josef Jancar

References

1. Gruenwald G (1992) Plastics, how structure determines properties. Hanser, Munich
2. Rubin II (ed) (1990) Handbook of plastic materials and technology. J Wiley Interscience, New York

Contents