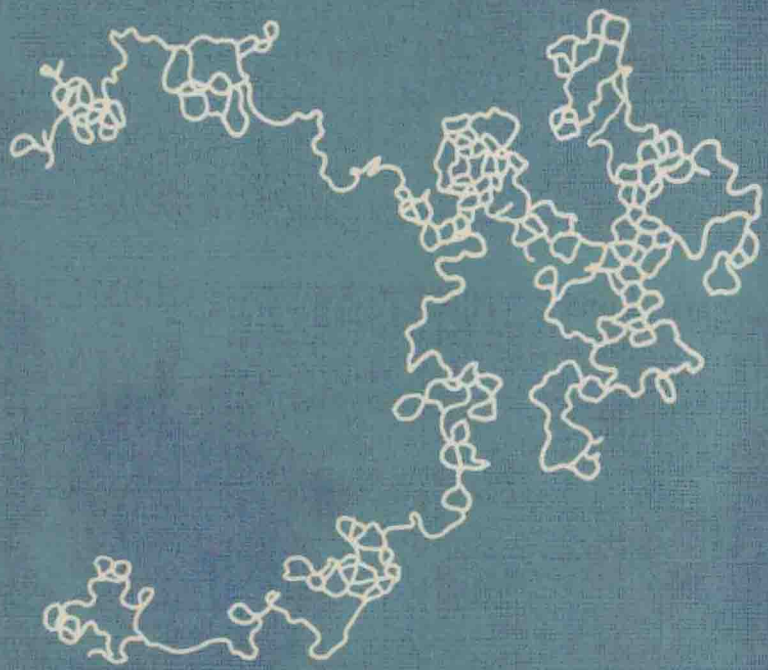
RUBBERY MATERIALS and their compounds



J. A. BRYDSON

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J. A. BRYDSON

Formerly Head, Department of Physical Sciences and Technology, Polytechnic of North London, UK

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RUBBERY MATERIALS AND THEIR COMPOUNDS

Preface

Whilst there are a number of texts on the chemistry of rubbers and on a general overview of rubber technology I have been aware for some time of a lack of a single-volume text that surveys rubbers as materials. It is the aim of this book to provide such a text reviewing the polymers available, explaining the differences between grades within a polymer type, additives used in rubber compounds and then indicating with reference to specific products how polymers and additives may be formulated to give suitable compounds.

In some ways this may be considered as being intermediate to two earlier texts of mine, *Plastics Materials* and *Rubber Chemistry*. Although covering the same group of materials as the latter, *Rubbery Materials* has more the format of the former with emphasis on technology and application rather than on theoretical chemistry. However, because of its relevance to the subject matter of this text, Chapter 3 on structure and properties is closely based on Chapter 4 of *Rubber Chemistry*.

The text may be considered in four, unequal, parts. The first three chapters are general, covering the historical development of rubbery materials and the relationship between structure and properties. The next thirteen, and thus the main body of the book, provide a review of the various commercial rubbery polymers including their preparation, structure, properties, compounding, processing and applications. The next five chapters are concerned with additives whilst a final chapter considers compound design in the light of the contents of the previous chapters.

I have taken some topics out of the main body of the book. As a prefix I have listed common abbreviations for elastomeric materials whilst in appendices I have tabulated some specific gravities of additives, presented a note on the use of the Mooney viscometer, results from which are quoted in most chapters, given some references to additional general literature sources and described an ASTM system of classification of rubbers. After some indecision I have located a tabulated summary of the properties of the major rubbers in the last chapter.

For such a wide-ranging survey as this text provides I must acknowledge not only much original research and development work but also many

excellent review papers, especially those in *Rubber Chemistry and Technology*. Amongst other important sources are the publications of David Blackley, Ken Lee and Tony Whelan, whom I was privileged to have as members of staff in my department at the Polytechnic of North London for several years. My thanks are also due to the Polytechnic for generously providing me, as an ex-member of staff, with library and other facilities.

I should also like to acknowledge the excellent trade manuals and other publications of polymer manufacturers whose staff were extremely helpful. In particular I would like to thank Bayer, B. F. Goodrich, Bunawerke Hüls, Dow Corning, Du Pont, Polysar, Shell International and Wacker amongst manufacturers and the Malaysian Rubber Producers' Research Association and the International Institute of Synthetic Rubber Producers for their assistance.

A Note on Abbreviations

In the text I have frequently made use of abbreviations. In the case of rubbery polymers I tried to ensure that the first time an abbreviation is used the full name is given alongside. However a list of abbreviations for rubbers is given on pages xix–xxi for ready reference. I have also made wide use of abbreviations for accelerators, in some cases without spelling out the full name the first time the abbreviation is used. The abbreviations for the principal accelerators with their chemical name and main characteristics are given on pages xxi–xxii and in Table 18.1. In the case of other additives I have used the full name alongside the abbreviation on the first occasion but Chapters 19–21 should be used for reference purposes.

J. A. BRYDSON

Abbreviations

STANDARD ABBREVIATIONS FOR RUBBERY MATERIALS

(Based on ISO Recommendation R1629 and ASTM D 1418)

ABR	Acrylate–butadiene rubber
ACM	Copolymer of ethyl or other acrylates and a small amount of a monomer which facilitates vulcanization
AECO	Terpolymer of allyl glycidyl ether, ethylene oxide and epichlorhydrin
AEM	Copolymer of ethyl or other acrylate and ethylene
AFMU	Terpolymer of tetrafluoroethylene, trifluoronitrosomethane and nitrosoperfluorobutyric acid
ANM	Copolymer of ethyl or other acrylate and acrylonitrile
AU	Polyester urethane
BIIR	Bromo-isobutene–isoprene rubber (brominated butyl rubber)
BR	Butadiene rubber
CFM	Polychlorotrifluoroethylene
CIIR	Chloro-isobutene–isoprene rubber (chlorinated butyl rubber)
CM	Chlorinated polyethylene
CO	Epichlorhydrin rubber
CR	Chloroprene rubber
CSM	Chlorosulphonated polyethylene
ECO	Ethylene oxide and epichlorhydrin copolymer
EAM	Ethylene–vinyl acetate copolymer
EPDM	Terpolymer of ethylene, propylene and a diene with the residual unsaturated portion of the diene in the side chain
EPM	Ethylene–propylene copolymer
EU	Polyether urethane
FFKM	Perfluoro rubber of the polymethylene type having all substituent groups on the polymer chain either fluoro, perfluoroalkyl or perfluoroalkoxy groups
FKM	Fluororubber of the polymethylene type having substituent fluoro and perfluoroalkoxy groups on the main chain

FVMQ	Silicone rubber having fluorine, vinyl and methyl substituent groups on the polymer chain
GPO	Polypropylene oxide rubber
IIR	Isobutene–isoprene rubber (butyl rubber)
IM	Polyisobutene
IR	Isoprene rubber (synthetic)
MQ	Silicone rubber having only methyl substituent groups on the polymer chain
NBR	Nitrile–butadiene rubber (nitrile rubber)
NIR	Nitrile–isoprene rubber
NR	Natural rubber
PBR	Pyridine–butadiene rubber
PMQ	Silicone rubber having both methyl and phenyl groups on the polymer chain
PSBR	Pyridine–styrene–butadiene rubber
PVMQ	Silicone rubber having methyl, phenyl and vinyl substituent groups on the polymer chain
Q	Rubber having silicon in the polymer chain
SBR	Styrene–butadiene rubber
T	Rubbers having sulphur in the polymer chain (excluding copolymers based on CR)
VMQ	Silicone rubber having both methyl and vinyl substituent groups in the polymer chain
XNBR	Carboxylic–nitrile butadiene rubber (carboxynitrile rubber)
XSBR	Carboxylic–styrene butadiene rubber
Y	Prefix indicating thermoplastic rubber
YBPO	Thermoplastic block polyether–polyester rubbers

MISCELLANEOUS ABBREVIATIONS FOR RUBBERY MATERIALS

In addition to the nomenclature based on ISO and ASTM recommendations, several other abbreviations are widely used. Those most likely to be encountered are:

ENR	Epoxidized natural rubber
EPR	Ethylene–propylene rubber (either EPM or EPDM)
EVA	Ethylene–vinyl acetate copolymer (instead of EAM)
OESBR	Oil-extended SBR

SBS	Styrene–butadiene–styrene triblock copolymer
SEBS	Hydrogenated SBS
SIR	Standard Indonesian Rubber
SIS	Styrene–isoprene–styrene triblock copolymer
SMR	Standard Malaysian rubber

During the Second World War the United States Government introduced the following systems of nomenclature which continued in use, at least partially, until the 1950s and is used in many publications of the period.

GR–A	Government Rubber–Acrylonitrile (modern equivalent, NBR)
GR–I	Government Rubber—Isobutylene (IIR)
GR–M	Government Rubber—Monovinyl acetylene (CR)
GR–P	Government Rubber—Polysulphide (T)
GR–S	Government Rubber—Styrene (SBR)

ABBREVIATIONS FOR SOME COMMON VULCANIZATION ACCELERATORS

BDTM	2-benzothiazole-dithio-*N*-morpholine
CBS	*N*-cyclohexylbenzothiazole-2-sulphenamide
DCBS	*N*,*N*-dicyclohexylbenzothiazole-2-sulphenamide
DOTG	Di-*o*-tolylguanidine
DPG	Diphenylguanidine
DPTT	Dipentamethylene thiuram tetrasulphide
DTDM	4,4′-dithiodimorpholine
MBS	*N*-morpholinothiobenzothiazole-2-sulphenamide
MBT	2-mercaptobenzothiazole
MBTS	Dibenzothiazole disulphide
NOBS	*N*-oxydiethylbenzothiazole-2-sulphenamide
OTOS	*N*-oxydiethylenethiocarbamyl-*N*-oxydiethylene sulphenamide
PPD	Piperidine pentamethylene dithiocarbamate
SDC	Sodium diethyldithiocarbamate
SIX	Sodium isopropylxanthate
SMBT	Sodium mercaptobenzothiazole
TBBS	*N*-*t*-butylbenzothiazole-2-sulphenamide
TDEDC	Tellurium diethyldithiocarbamate
TETD	Tetraethylthiuram disulphide
TMTD	Tetramethylthiuram disulphide
TMT	Tetramethylthiuram disulphide

TMTM	Tetramethylthiuram monosulphide
TPG	Triphenylguanidine
ZBDP	Zinc dibutyldithiophosphate
ZBX	Zinc butylxanthate
ZDC	Zinc diethyldithiocarbamate
ZEDC	Zinc diethyldithiocarbamate
ZDBC	Zinc dibutyldithiocarbamate
ZDMC	Zinc dimethyldithiocarbamate
ZIX	Zinc isopropylxanthate
ZMBT	Zinc mercaptobenzothiazole

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