

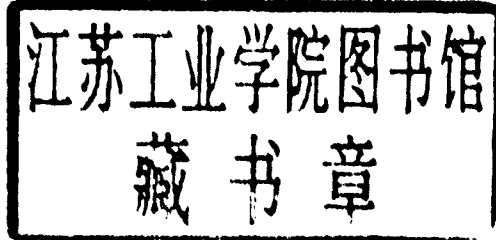
Chemistry and Technology of Polyols for Polyurethanes

Mihail Ionescu

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This book is dedicated to the memory of Dr Jack Buist, an exceptional personality in the field of polyurethane chemistry and technology. His vision on the advanced technologies in the polyurethane industry, his brilliant scientific activity leading to unanimous worldwide recognition, the exceptional career at ICI Polyurethanes, his work as founding editor of the international journal, *Cellular Polymers and Progress* has had great impact on the general worldwide development of polyurethane chemistry and polyurethane technology in the last five decades of the twentieth century. Dr Jack Buist will be forever, one of polyurethane's great men and has truly earned his place alongside Professor Otto Bayer, Professor Kurt C Frisch, Dr Adnan AR Sayigh, Dr Carlo Fiorentini and Dr Guenter Oertel in the Polyurethane's Hall of Fame.

Preface

The first polyurethane synthesised by Dr Otto Bayer, in 1937, at IG Farbenindustrie (Germany), by the reaction of a polyester diol with a diisocyanate, opened a new way in macromolecular chemistry: that is the synthesis of polymers by a new reaction, called polyaddition reaction.

Polyurethanes, having a relatively short history, of slightly more than 65 years, became one of the most dynamic groups of polymers, and their use covers practically all the fields of polymer applications - foams, elastomers, thermoplastics, thermorigid, adhesives, coatings, sealants, fibres and so on. Polyurethanes are used in nearly every aspect of daily life, changing the quality of human life. Furniture, bedding, seating for cars, shoe soles, thermoinsulation for refrigerators and buildings, wood substitutes, packaging, and coatings, are only a few common examples of polyurethane use in every day life.

Polyurethanes are obtained by the reaction of an oligomeric polyol (low molecular weight polymer with terminal hydroxyl groups) and a diisocyanate (or polyisocyanate). The structure of the oligomeric polyol used for polyurethane manufacture has a very profound effect on the properties of the resulting polymer.

The present monograph is dedicated to these very important raw materials used to build the polyurethane polymeric architecture: and covers chemistry and technology of oligomeric polyol fabrication, properties of these hydroxyl terminated oligomers and the effects of the oligomeric polyol structure on the resulting polyurethane properties.

So as not to be confused over the term 'polyol' some explanations are necessary. Generally, the term 'polyol' is used, in organic chemistry, for low molecular weight organic substances, very clearly identified as molecular entities, having more than two hydroxyl groups, such as: glycerol, propylene glycol, sorbitol and so on. The term 'polyol', is frequently used in relation to polyurethane fabrication, for all polyhydroxylic intermediates used. To be very clear, the present monograph is a study exclusively focused on oligomeric polyols, particularly low molecular weight polymers with terminal hydroxyl groups, covered by the general term of 'oligo-polyols'. These oligo-polyols are not unique molecular species,

being similar to all the polymers: a mixture between homologue species with various molecular weights (they have a molecular weight distribution). These oligo-polyols have an average molecular weight, by contrast with the low molecular weight of the polyols from organic chemistry which have a clear and unique molecular weight. In the text of this monograph, if the chemical nature of oligo-polyol is known, before the name 'polyol' is used the chemical name of the oligomeric chain, such as: polyether polyols, polyester polyols, polycarbonate polyols, acrylic polyols, Mannich polyols and so on. If the oligomeric polyols, are discussed generally, the term used will be 'oligo-polyol'.

Many excellent monographs have been dedicated to polyurethanes and, of course, the oligo-polyols were described there, but in a very general manner. The present monograph goes into the details of oligo-polyols synthesis in depth, and explains the chemical and physico-chemical subtleties of all oligo-polyol fabrications.

A large variety of chemical reactions for the synthesis of oligo-polyols to build the chemical architecture of oligo-polyols are used, such as: ring opening polymerisation of cyclic monomers by anionic, cationic or coordinative mechanisms, polycondensation reactions (polyesterification, transesterification, Mannich reactions, phenol-aldehydes condensations and so on), alkoxylation, radical polymerisation, transformation of double bonds in hydroxyl groups, such as: epoxydation-hydrolysis, hydroxylation, hydroformylation, ozonolysis-reduction and so on), oxidation and amidation reactions. These varieties of chemical reactions need serious knowledge of organic and macromolecular chemistry and the author tries to explain, in a very simple and accessible manner, the very complex phenomena involved in oligo-polyol fabrication.

The scientific literature dedicated to oligo-polyols is really impressive and the majority of information is based on the patent literature. The scientific literature, dedicated exclusively to oligo-polyols for polyurethanes is unexpectedly scarce. As an immediate consequence, the present monograph is based especially on the patent literature and on the personal experience of the author, who has worked for more than 30 years, on the synthesis of oligo-polyols for polyurethanes. As mentioned before, there are excellent books dedicated to polyurethanes and an excellent book dedicated to the chemistry and technology of isocyanates. The present monograph, dedicated to the second very important component of polyurethane fabrication, oligo-polyols, tries to complete this series of monographs in a logical manner.

This book attempts to link in a general concept, organised in a systematic manner, the most important knowledge, data and information concerning the chemistry and technology of oligo-polyols for polyurethanes. This general point of view resulting from the fact that all oligo-polyols used for polyurethanes have many things in common, will be presented, in detail, in this monograph. In order not to provide too much information, and to avoid presentation of confidential data, the commercial names of the oligo-polyols are

not mentioned. Thus, each oligo-polyol is identified by the chemical structure or by the chemical name. At the same time and for the same reasons, the names of companies which developed and produced the various types of common oligo-polyols are not mentioned. The commercial name and the company name is specified exceptionally, only for the unanimously accepted very important developments in the area of oligo-polyols (e.g., PHD-polyols of BAYER and so on).

Of course, it is totally impossible to cover all the aspects and to describe all the oligo-polyol structures created as a consequence of the impressive worldwide creative effort of research laboratories from companies, universities, research centers and institutes, but I am sure that the most important aspects of oligo-polyol manufacture are presented.

The present monograph is addressed to all specialists working in the area of oligo-polyols for polyurethanes: students, researchers, scientists, engineers, professors, experts from: industry, universities, research centers and research institutes.

I hope that the monograph will be the start for new and original and developments in the area of oligo-polyols for polyurethanes, including creation of totally new oligo-polyols, with a new design and new chemical architecture, and of course for new technologies and unconventional manufacturing technologies.

Good luck!

I express my profound gratitude to my wife Adriana for her continuous and unconditional help and support.

I am grateful to, and I thank very much Ms Frances Powers, Senior Commissioning Editor, Rapra Technology, for her tenacity, patience, attention, high competency and professionalism to review and correct each page, each table, each formula, each sentence, each reference, each word, each sign and to produce the book to such standard. I am also grateful to Frances, for the fact that all the time she believed in me, and in my capability to finish the book.

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Mihail Inonescu

August 2005

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