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Advances in Silicon Science is a book series which presents reviews of the present and future trends in silicon science and will benefit those in chemistry, physics, biomedical engineering, and materials science. It is aimed at all scientists at universities and in industry who wish to keep abreast of advances in the topics covered.

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Volume 4

Silicone Surface Science

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Preface

God made the bulk; surfaces were invented by the devil
Wolfgang Pauli[1]

It is somewhat surprising, in our opinion, that this book, to the best of our knowledge, is the first to be devoted to the surface properties and behavior of silicone polymers. The situation is all the more perplexing when one considers that surface-related applications have consistently accounted for the major part of the commercial success of silicones since the establishment of this industry in the early 1940s.

The importance of surfaces and interfacial phenomena cannot be overemphasized. When any two materials are brought together it is their surfaces that initially matter and their interfacial interactions that need to be studied and understood first. Therefore, in order to contribute to this, in this book we attempt to present a broad overview of the state-of-the-art of silicone surface science by a group of widely recognized experts in their fields summarizing both the historical development and the current progress in each selected area. With almost 70 years of scientific and technological interest in silicones we can hardly claim to be rigorously comprehensive, but we are sure that the most exciting developments in this field today are covered in this volume.

Much of the content of this book deals with polydimethylsiloxane (PDMS) since it has been the mainstay of the silicone industry from its very beginnings to the present day. Furthermore, looking into the future, while anticipating continued interest in and development of other polymers derived from organosilicon entities, there is no reason not to believe that the science and applications of PDMS and related organosiloxane polymers will continue to grow and play as important a role as they have in the past.

As is common in the field of silicon-containing polymers, we use the term silicone to describe polymers whose backbone is siloxane, i.e. alternating arrangement of silicon and oxygen atoms, with pendent organic groups attached to that backbone. Consequently, polyhedral oligomeric silsesquioxanes (POSS), which certainly meet

[1] Quoted in "*Growth, Dissolution and Pattern Formation in Geosystems*" (1999) by Bjorn Jamtveit and Paul Meakin, p. 291.

the "alternating siloxane bonds" requirement, are not usually considered "silicones", because of their insufficient molecular weights and fundamentally different macroscopic properties. Nevertheless, we consider these oligomers to be a proper subject for inclusion in this volume because of their critical importance to silicone surface science as explained in detail in two chapters dealing with POSS derivatives.

What might appear to some to be a somewhat capricious chapter order is based on our attempt to marry two seemingly "incompatible" concepts: (i) a progressive shift from fundamentals to more applied topics, and (ii) a development from "pure" PDMS to other important, surface-active silicones such as fluorosilicones and modified materials such as surfactants and coupling agents. The book opens with a general introduction to silicone surfaces with an emphasis on the surface properties of PDMS. Following this, in Chap. 2 Ahn and Dhinojwala describe the sum frequency generation vibrational spectroscopy of silicone surfaces and interfaces, a relatively recently introduced technique that has provided considerable new insight into surface structure and most notably to buried interfaces as well. Genzer and co-workers have made great strides in creating different functionalities on silicone surfaces and their contributions are reviewed in Chap. 3. Superhydrophobic surfaces have featured strongly in the last decade, and McCarthy et al. review their silane/siloxane studies of this topic in Chap. 4. Chapters 5 and 6 deal with fluorine-containing silicones where Ganachaud and Ameduri and their colleagues review structure/property relationships in fluorosilicones and Tuteja and Mabry contribute a chapter on fluoro-POSS materials which are highly relevant to the earlier topic of superhydrophobicity, respectively. Our strong interest in fluorosilicones derives from their potential to produce significantly lower surface energies than conventional PDMS surfaces.

Langmuir trough investigations of silicones have been of interest since surface studies of silicones began. In Chap. 7 Esker and Yu provide a summary of this topic with an update of recent works that offers another facet of the growing importance of POSS compounds to organosilicon surface science today. A topic of high-interest to current siloxane science with considerable surface-related implications is the interaction of proteins and silicon-based materials which is the subject of Chap. 8 by Clarson and co-workers. This is followed by a review of silicone surfactant fundamentals and applications by Snow and Petroff in Chap. 9, while Matisons' Chap. 10 deals with the adsorption of polymeric siloxanes on glass surfaces and their coupling behavior as well as with more conventional silane coupling agents. Surface treatments such as plasma and corona have been widely exploited in silicone surface modification. These are summarized in Chap. 11 by Hillborg and Gedde (see also Chap. 3 which deals with aspects of this topic).

Analytical techniques are self-evidently central to understanding of silicone surface behavior. A review of these studies with emphasis on X-ray photoelectron spectroscopy (XPS), secondary ion mass spectrometry (SIMS), scanning electron microscopy (SEM) and scanning probe microscopy (SPM) is provided by Leadley, O'Hare and McMillan in Chap. 12. Finally, we close with an outline of some important surface applications of silicones relating to both the science and technology of silicone surfaces. Some of these applications are also included in several of the earlier chapters, underlining a dominant theme of this book, the relationship between

the structure and surface properties of silicones and their utilization in various everyday as well as more sophisticated applications.

A variety of authors contributed different perspectives to this work, including academic and industrial specialists from Europe and North America. We sincerely thank all of them for their impressive contributions and their patience and perseverance throughout the process of bringing this book to fruition. We are particularly grateful to our publishing editor, Dr. Sonia Ojo and her Springer colleagues for their expert help during the preparation of the manuscript and to Donatas Akmanavičius of VTeX UAB in the realization of this finished work.

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