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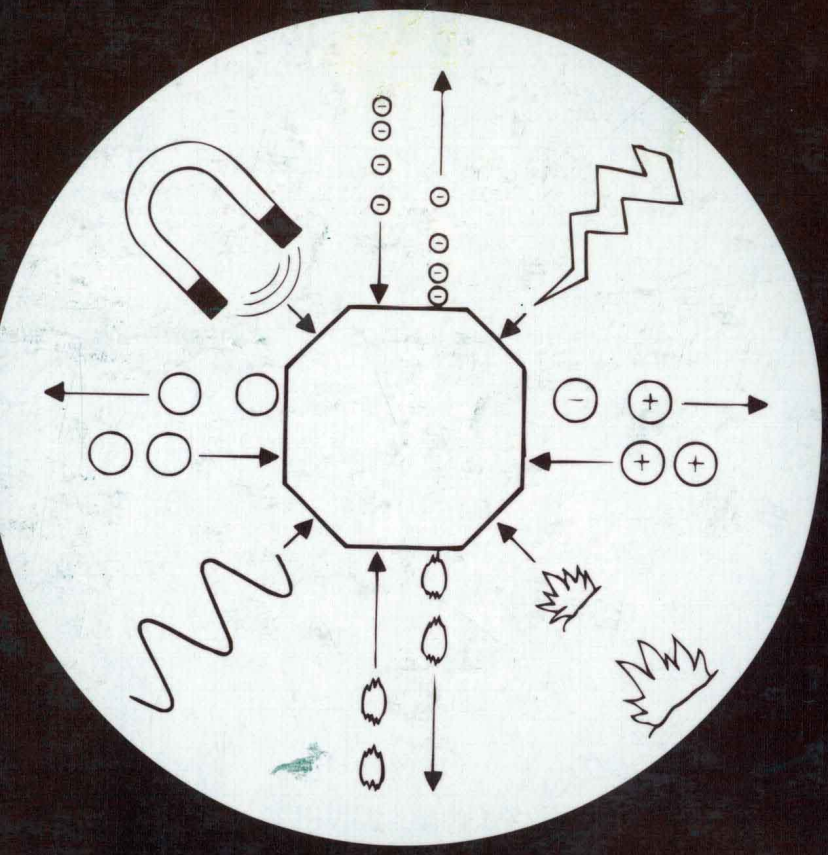

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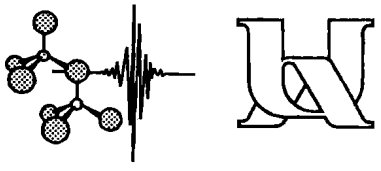

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Preface

Oxide surface materials are widely used in many applications, in particular where chemically modified oxide surfaces are involved. Indeed, in disciplines as separations, catalysis, bioengineering, electronics, ceramics, etc. modified oxide surfaces are very important. In all cases, the knowledge of their chemical and surface characteristics is of great importance for the understanding and eventual improvement of their performances.

The purpose of this book is essentially to cover techniques and procedures characterizing and modifying the silica surface. We hope that this book will be useful for all those who, working at the graduate student or research worker level, are interested in the chemistry of silica and chemically modified oxide surfaces.

The content of this book reviews the latest developments in the characterization and chemical modification of silica surfaces. No attempt has been made to survey exhaustively the literature of any topic. The material has been collected from recent publications and own research work in this field. Also, recent disclosures of research activities in the former USSR are documented in detail in the text.

The book is divided into three major parts. The first part (Part I) reviews the characterization of the silica surface, discussing the preparation and properties of pure silica (Chapter 1), the physical characterization of the silica surface (Chapter 2), the chemistry of silica (Chapter 3), the quantification of the silanol number (Chapter 4), the distribution of the silanol types and their desorption energies (Chapter 5), the effect of surface morphology on the dehydroxilation behaviour (Chapter 6) and the related silicate materials (Chapter 7). Part II discusses the chemical modification of

the silica surface, covering the procedures for a chemical modification of the silica surface and their applications (Chapter 8), the modification with silicon compounds (Chapter 9), the modification with boron compounds (Chapter 10) and the use of other modifiers (Chapter 11) including the ammoniation of modified silicas to introduce functional groups on the surface (Chapter 12). The third part (Part III) describes the chemical surface coating technique (Chapter 14) with respect to other surface coating methods (Chapter 13). Furthermore, the principles of the most frequently used surface analysis techniques are briefly described in the annexes A, B, C and D.

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Etienne F. Vansant is presently Professor in Inorganic Chemistry at the University of Antwerp (UIA), Belgium. He has served as Visiting Professor, Research Associate and Invited Consultant in several universities and companies in the field of material science. Professor Vansant's research interests include the optimalization of gas separation and purification techniques for both industrial and ecological purposes, the conditioning and purification of waste waters and soils, and the development of new materials.

Pascal Van Der Voort is presently senior research assistant at the Laboratory of Inorganic Chemistry (University of Antwerp). He was granted the title of Doctor in Sciences for his pioneering work on Chemical Surface Coating. After that, Dr. Van Der Voort stayed strongly involved in the research on chemically modified oxide surfaces and their application as ceramics and catalysts.

Karl C. Vrancken is presently a researcher at the Laboratory of Inorganic Chemistry (University of Antwerp). In this position he substantiated the development of the Chemical Surface Coating method. In his young career as a Doctor in Sciences, he gained full expertise in organosilane chemistry. His current work is concerned with surface modifications and advanced materials preparation.

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CHARACTERIZATION OF THE SILICA SURFACE

PART 1: THE SILICA SURFACE

Chapter 1

Silica: preparation and properties

1 Introduction: natural and synthetic silica

The name silica comprises a large class of products with the general formula SiO_2 or $SiO_2.xH_2O$. Silica is a naturally occurring material in minerals, such as quartz and flint, and in plants such as bamboo, rice and barley. Most of the silica used in chemical applications however, has a synthetic origin. In its natural form it mostly occurs as a crystalline phase. Various phases may be formed, depending on temperature, pressure and degree of hydration. At atmospheric pressure the anhydrous crystalline silica may be classified in the following phases, according to the temperature:

$$\text{quartz} \xrightleftharpoons{1143\ \text{K}} \text{tridymite} \xrightleftharpoons{1743\ \text{K}} \text{cristobalite}$$

At 1973 K cristobalite is transformed to amorphous vitreous silica glass. The crystalline form involves a high degree of ordering in a dense structure. The active surface, which may participate in any chemical or physical interaction, is limited to the external surface of the crystalline particles. The specific surface area therefore is similar to the geometric surface.