

PHYSICAL CHEMISTRY OF SURFACE PHENOMENA

Properties of the Surface of Silicas Modified with Bi- and Trifunctional Perfluorohexylsilanes: Adsorption of Benzene

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Abstract—Diffuse reflection IR spectroscopy, static adsorption, and gas chromatography were used to study the chemistry and adsorption properties of the surface of silicas modified by chemically grafted bi- (C_6F_{13} (II)) and trifunctional (C_6F_{17} (III)) perfluorohexylsilanes. It was established that the modification of silica (SiO_2) results in a nearly complete screening of free silanols. At the same time, IR spectra featured absorption bands belonging to weakly perturbed OH groups capable of interacting with benzene molecules. The IR spectroscopy data on benzene adsorption were found to be in close agreement with the results of static adsorption and chromatographic measurements, according to which the specific amount of benzene adsorbed decreases in the series $SiO_2 > C_6F_{17}$ (III) $>$ C_6F_{13} (II). It was demonstrated that the heat of adsorption of benzene on the C_6F_{17} (III) sample is higher than that on the initial carrier. Grafted layers prepared from the trifunctional modifier exhibited higher efficiency in preventing benzene molecules from reaching the carrier surface.

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The modification of surfaces with compounds containing perfluoroalkyl groups with a high degree of fluorination is used in solving a number of fundamental and practical problems, including the production of sorbents for high-performance liquid chromatography, coatings for microelectronic, and materials for medicine [1–6]. How successfully these problems can be tackled depends on knowledge of the properties of surfaces modified by fluorine-containing compounds.

The performance characteristics of modified materials are known to be determined not only by the chemical nature of grafted groups but also by their distribution over the surface and the character of interaction with neighboring groups. A significant contribution to the properties of chemically modified silicas (CMSs) comes from silanol groups that survive the modification of the surface with organosilanes. For bi- and trifunctional silanes (the functionality of organosilanes modifiers is defined as the number of active groups or atoms X capable of interacting with the silica surface), part of X groups remains unreacted, and, therefore, hydrolysis produces additional hydroxyls bonded to the silicon atom of the modifier molecule [1]:



where R is an organic radical and n is the functionality of the modifier ($n = 2$ or 3).

The presence of free OH groups is normally considered to be the main factor responsible for the poor reproducibility of adsorption properties and the nonuniformity of the surface of CMSs and an obstacle to attainment of the ultimate lyophobicity and antiadhesive properties of modifying coatings [1, 5]. The ability of some functional groups of a grafted molecule to interact with silanol groups through the establishment of hydrogen bonds may also produce a significant effect on the structure of the grafted layer due to the formation of so-called arc structures [1].

Recent successes in studies of surfaces by IR spectroscopy extended our knowledge of the detailed structure of the surface and, hence, its adsorption and catalytic properties [7, 8]. An important direction of research of equilibrium adsorption characteristics is based on classical adsorption methods and gas chromatography, with the latter being especially informative in studying the properties of materials over a wide temperature range at very low surface coverages [9]. To our knowledge, no data has so far been reported on the physicochemical properties of the surface of silicas modified by perfluorohexylsilanes with various functionalities.

In the present work, we studied the chemistry of the surface and adsorption properties of silicas coated by chemically grafted bi- and trifunctional perfluorohexylsilanes with the help of diffuse reflection IR spectroscopy, static adsorption, and gas chromatography.

The Surface Properties Of Silicas

M. J. Schick



The Surface Properties Of Silicas:

The Surface Properties of Silicas André P. Legrand, 1998-06-29 Each of the many different varieties of silica is characterised by its crystalline or amorphous structure and its specific physico chemical surface properties It is these surface characteristics which determine the applications of the silica be it for chromatography dehydration polymer reinforcement or other processes All the recent advances in the use of established and more modern methods for the determination of the surface and morphological characteristics of silicas are found in this book written by a team of European experts Analytical methods discussed include solid state nuclear magnetic resonance infra red spectroscopy and adsorption methods Emphasis is given to the nature and distribution of hydroxyl groups on silica surfaces the final chapter gives a general survey of the health and safety aspects of silica

The Properties of Silica Robert Browning Sosman, 1927 *Handbook Of Fillers For Plastics* H.S. Katz, J.V. Mieski, 1987-11-30 This book should be of interest to manufacturers of plastics products and fillers plastics designers engineers and polymer chemists

Adsorption on Silica Surfaces Eugene Papirer, 2000-04-05 Progresses from theoretical issues to applications Contains a historical overview in depth considerations of various scenarios of silica adsorption and results from the latest research Invaluable for broad coverage of the expanding field of silica research

Surface Characteristics of Fibers and Textiles M. J. Schick, 2017-09-19 The extraordinary growth in the production and use of man made fibers over the past few decades has focused attention on the surface properties of fibers and textiles This volume combines surface science and technology in its presentation of the substantial progress that has been made in the technology related to the surface characteristics of natural synthetic and glass fibers and textiles Adopting an interdisciplinary approach the coverage places emphasis upon the wetting soiling staining frictional and adhesive properties of fibers and fabrics as well as phenomena related to these properties The book offers critical reviews which describe experimental facts theories and processes Symbols are clearly defined in each chapter Among the subjects covered are the surface properties of glass fibers soil release stain and water repellance friction of fabrics bonding of nonwovens and the wetting of fibers Surface Characteristics of Fibers and Textiles Part II is an outstanding textbook for courses dealing with surface chemistry the mechanical properties of textiles textile technology and polymer chemistry It is also a valuable reference book designed to make current knowledge on these subjects accessible to industrial and academic researchers

Proceedings of the International Conference on Colloid and Surface Science Y. Iwasawa, N. Oyama, H. Kunieda, 2001-02-15 The purpose of this Conference was to discuss the results of recent developments and the future prospect in science and technology of the field The field has been growing and flourishing while indicating many problems to be uncovered and solved The conference was structured to encourage interaction and to stimulate the exchange of ideas to accomplish the above purpose Key issues and materials related to the Conference were included as follows Molecular Assemblies in Solutions Fine Particles and Colloidal Dispersions Supramolecular Organized Films Nanostructural Solid

Surfaces Industrial Applications and Products The Conference comprised 2 plenary lectures 42 invited lectures 150 oral presentations and 266 poster presentations *Encyclopedia of Surface and Colloid Science* P. Somasundaran, 2006 *The Surface Properties of Silica Gels* J. D. Madeley, 1958 **Encyclopedia of Surface and Colloid Science** - Arthur T. Hubbard, 2002-07-18 This comprehensive reference collects fundamental theories and recent research from a wide range of fields including biology biochemistry physics applied mathematics and computer materials surface and colloid science providing key references tools and analytical techniques for practical applications in industrial agricultural and forensic processes as well as in the production of natural and synthetic compounds such as foods minerals paints proteins pharmaceuticals polymers and soaps *Surface and Nanomolecular Catalysis* Ryan Richards, 2006-05-25 Using new instrumentation and experimental techniques that allow scientists to observe chemical reactions and molecular properties at the nanoscale the authors of *Surface and Nanomolecular Catalysis* reveal new insights into the surface chemistry of catalysts and the reaction mechanisms that actually occur at a molecular level during catalysis **Colloidal Silica** Horacio E. Bergna, William O. Roberts, 2005-12-19 In spite of the apparent simplicity of silica's composition and structure scientists are still investigating fundamental questions regarding the formation constitution and behavior of colloidal silica systems *Colloidal Silica Fundamentals and Applications* introduces new information on colloid science related to silica chemistry as well *Characterization and Chemical Modification of the Silica Surface* E.F. Vansant, P. Van Der Voort, K.C. Vrancken, 1995-04-25 Oxide surface materials are widely used in many applications in particular where chemically modified oxide surfaces are involved Indeed in disciplines such as separation 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 This book reviews the latest techniques and procedures in the characterization and chemical modification of the silica surface presenting a unified and state of the art approach to the relevant analysis techniques and modification procedures covering 1000 references integrated into one clear concept *Surface Chemistry in Biomedical and Environmental Science* Jonathan P. Blitz, Vladimir M. Gun'ko, 2006-09-09 In September 2005 a NATO Advanced Research Workshop convened in Kiev to discuss the current state of the art in surface chemistry and nanomaterials research with a view towards biomedical and environmental applications This volume represents the fine work presented at this workshop consisting of a unique mixture of reviews as well as primary research articles from leading laboratories in Eastern and Western Europe as well as the US A common theme throughout much of this volume involves adsorption and interfacial behavior of nanomaterials including core shell particles nanoparticles derived from oxides mixed oxides carbon carbon oxide hybrids functionalized nanoparticles polymeric biomaterials and more The behavior and design of these nanomaterials for adsorption or sometimes the lack thereof of toxins pollutants narcotics warfare agents and various biomolecules are studied with a mix of experimental and theoretical approaches This volume

holds a special niche in describing the current state of the art in the fundamentals and applications of a variety of nanomaterials

Nanostructures: Synthesis, Functional Properties and Application Thomas Tsakalakos, Ilya A. Ovid'ko, Asuri K. Vasudevan, 2012-12-06 The Advanced Study Institute on Synthesis Functional Properties and Applications of Nanostructures held at the Knossos Royal Village Heraklion Crete Greece July 26 2002 August 4 2002 successfully reviewed the state of the art of nanostructures and nanotechnology It was concluded that Nanotechnology is widely agreed to be the research focus that will lead to the next generation of breakthroughs in science and engineering There are three cornerstones to the expectation that Nanotechnology will yield revolutionary advances in understanding and application Breakthroughs in properties that arise from materials fabricated from the nanoscale Synergistic behavior that arise from the combination of disparate types of materials soft vs hard organic vs inorganic chemical vs biological vs solid state at the nanoscale Exploitation of natural e g chemical and biological assembly mechanisms that can accomplish structural control at the nanoscale It is expected that this will lead to paradigms for assembling bio inspired functional systems that accomplish desirable properties that are either unavailable or prohibitively expensive using top down approaches

Environmental Health Perspectives ,1993

Handbook of Surfaces and Interfaces of Materials, Five-Volume Set Hari Singh Nalwa, 2001-10-26 This handbook brings together under a single cover all aspects of the chemistry physics and engineering of surfaces and interfaces of materials currently studied in academic and industrial research It covers different experimental and theoretical aspects of surfaces and interfaces their physical properties and spectroscopic techniques that have been applied to a wide class of inorganic organic polymer and biological materials The diversified technological areas of surface science reflect the explosion of scientific information on surfaces and interfaces of materials and their spectroscopic characterization The large volume of experimental data on chemistry physics and engineering aspects of materials surfaces and interfaces remains scattered in so many different periodicals therefore this handbook compilation is needed The information presented in this multivolume reference draws on two decades of pioneering research on the surfaces and interfaces of materials to offer a complete perspective on the topic These five volumes Surface and Interface Phenomena Surface Characterization and Properties Nanostructures Micelles and Colloids Thin Films and Layers Biointerfaces and Applications provide multidisciplinary review chapters and summarize the current status of the field covering important scientific and technological developments made over past decades in surfaces and interfaces of materials and spectroscopic techniques with contributions from internationally recognized experts from all over the world Fully cross referenced this book has clear precise and wide appeal as an essential reference source long due for the scientific community The complete reference on the topic of surfaces and interfaces of materials The information presented in this multivolume reference draws on two decades of pioneering research Provides multidisciplinary review chapters and summarizes the current status of the field Covers important scientific and technological developments made over past decades in surfaces and interfaces of

materials and spectroscopic techniques Contributions from internationally recognized experts from all over the world

Surface Chemical Compounds and Their Role in Adsorption Phenomena A. Kiselev, 1959 Concise Encyclopedia of High Performance Silicones Atul Tiwari, Mark D. Soucek, 2014-04-03 The encyclopedia will be an invaluable source of information for researchers and students from diverse backgrounds including physics chemistry materials science and surface engineering biotechnology pharmacy medical science and biomedical engineering

Small Particles Technology Jan-Erik Otterstedt, Dale A. Brandreth, 2013-03-09 It is difficult to imagine modern technology without small particles 1 1000 nm in size because virtually every industry depends in some way on the use of such materials Catalysts printing inks paper dyes and pigments many medicinal products adsorbents thickening agents some adhesives clays and hundreds of other diverse products are based on or involve small particles in a very fundamental way In some cases finely divided materials occur naturally or are merely a convenient form for using a material In most cases small particles play a special role in technology because in effect they constitute a different state of matter because of the basic fact that the surface of a material is different from the interior by virtue of the unsaturated bonding interactions of the outermost layers of atoms at the surface of a solid Whereas in a macroscale particle these differences are often insignificant as the surface area per unit mass becomes larger by a factor of as much as 10 physical and chemical effects such as adsorption become so pronounced as to make the finely divided form of the bulk material into essentially a different material usually one that has no macroscale counterpart

Surfaces of Nanoparticles and Porous Materials James A. Schwarz, Cristian I. Contescu, 1999-01-21 This innovative reference collects state of the art procedures for the construction and design of nanoparticles and porous material while suggesting appropriate areas of application Presenting both synthesis and characterization protocols Surfaces of Nanoparticles and Porous Materials contains over 3000 references tables equations drawings and photographs It examines the thermodynamics and kinetics of adsorption involving organic and inorganic liquids solids and gaseous media Topics include characterization transport processes diffusion and the adsorption of heavy metals ions proteins and pharmaceutical organics

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