

Chapter 1 : Surface Chemistry - Study Material for IIT JEE | askIITians

Surface chemistry research is an interdisciplinary area on the frontiers of physical chemistry and nanoscience. Residual unbalanced forces exist on the surface of a solid. Residual unbalanced forces exist on the surface of a solid.

Polyurethanes form some of the highest-performance coatings available. A variety of formulations is marketed. One type is a one-component one-pot prepolymer containing excess isocyanate groups. Upon application of the liquid to a surface, these groups react with water from the atmosphere to form a polymer film. Polymer-based surface coatings can be considered to be two-phase composite materials consisting of pigment particles and other additives dispersed in a continuous matrix of polymer. Polymers provide the coating film its capacity to adhere to the substrate, most of its chemical resistance, and flexibility. In addition, the continuity of the film, much of its durability in the presence of environmental stresses, its gloss properties, most of its mechanical and thermal properties, and most of any chemical reactivity that the film will exhibit are dependent on polymers as well. The key properties of the coating polymer are molecular weight, molecular weight distribution, glass transition temperature T_g , and solubility. Also important are the reactive molecular groups making up the polymer and the kinetics and mechanism by which the polymer is formed—that is, whether it is formed by step-growth polymerization or chain-growth polymerization. These two polymerization reactions are described in detail in the article industrial polymers, chemistry of. Another key attribute of the polymer is its structure. Polymers can have linear, branched, or network architectures see Figures 1A, 1B, and 1C of industrial polymers, chemistry of. The latter type of structure, consisting of polymer chains bonded covalently at several sites to form a three-dimensionally cross-linked network, is often formed in the coating film during its curing. Three common polymer structures. The chemical structure and molecular structure of highlighted regions are also shown. Step-growth and chain-growth polymers

Step-growth polymers include polyesters, epoxies, polyurethanes, polyamides, melamine, and phenolic resins. They are formed most often by reactions between two dissimilar monomers—acids and alcohols in the case of polyesters. This general class of polymers is used widely in the field of organic coatings. Chain-growth polymers are built up by the opening of carbon-carbon double or sometimes triple bonds within the monomers and the successive addition of similar monomers onto the ends of a growing chain. Prominent chain-growth polymers in the area of coatings are polyethylene, polystyrene, polymethyl methacrylate, and polyvinyl chloride. When used in nonreactive form, chain-growth polymers are usually thermoplastic, high-molecular-weight materials. In some cases, however, carboxylic acid, alcohol, epoxy, amine, amino, and other reactive groups can be incorporated into chain-growth polymers. With such reactive functionality on the polymer chain, these materials can be used in low-molecular-weight form as coreactants in cross-linking systems. For coatings use, one specific chain-growth polymerization method is utilized extensively—the latex, or emulsion, process. In its simplest form as shown in Figure 1, the emulsion process involves stabilizing large droplets of a monomer or monomers in water using a soap as a surface-acting agent, or surfactant. A water-soluble free-radical initiator is added, forming the latex particles by polymerization within small aggregates, called micelles, that are formed by the surfactant. Because latex coatings are applied as aqueous dispersions of polymer, their use is largely solvent-free, and they are very attractive for retail because they can be cleaned up with soap and water, are very easy to apply, and are durable. Latex polymers form films by particle-particle coalescence processes, discussed below. Schematic diagram of the emulsion-polymerization method. Monomer molecules and free-radical initiators are added to a water-based emulsion bath along with soaplike materials known as surfactants, or surface-acting agents. The surfactant molecules, composed of a hydrophilic water-attracting and hydrophobic water-repelling end, form a stabilizing emulsion before polymerization by coating the monomer droplets. Other surfactant molecules clump together into smaller aggregates called micelles, which also absorb monomer molecules. Polymerization occurs when initiators migrate into the micelles, inducing the monomer molecules to form large molecules that make up the latex particle. Polymer film-forming processes Upon application by spraying, brushing, or various industrial processes, surface coatings undergo what is known as film formation.

In most film-formation processes, a liquid coating of relatively low viscosity is applied to a solid substrate and is cured to a solid, high-molecular-weight, polymer-based adherent film possessing the properties desired by the user. For most common applications, this film has a thickness ranging from 0. Coatings before the s were often liquids of low solids content, from which considerable organic solvent was emitted into the atmosphere during film formation. Environmental and economic pressures have forced a reduction of solvent levels in coatings and have required coatings designers to reconsider and improve film-formation processes. As a result, there are now three major types of film processes: For a specific coating, the overall film-formation process actually may be a mixture of these three. Cross-linking film formation Some of the highest-performance coatings films are based totally on the reacting of polymer precursors to build up a three-dimensionally cross-linked network. This is at once both a very old and a very new technology. During the Middle Ages drying oils were used without solvent to formulate a paint that formed films totally by oxidative cross-linking. Drying oils are natural products such as linseed oil or tung oil that contain at least 50 percent unsaturated fatty acid triglycerides. When they react with oxygen in the air, these oils cross-link to form network polymers that have decorative and protective properties. Drying oils modified with soluble natural resins such as tree gum and rosin and naturally derived solvents such as turpentine are known as varnishes. When cast and allowed to dry more accurately, harden on various substrates, varnishes form films by evaporation of the solvent and by the cross-linking reactions of the unsaturated fatty acids in the oils. The cross-linking reactions are quite complex, but they essentially involve the addition of atmospheric oxygen to the fatty acids, leading to the formation of hydroperoxide derivatives of the fatty acids. These hydroperoxides decompose, especially in the presence of driers such as white lead or cobalt naphthenate, to form free radicals, which then cross-link with the remaining unsaturated fatty acid. New cross-linking technologies are based on two-component percent-solids reactive systems that are mixed just prior to or during application and form the final polymer coating by rapid cross-linking. An example is the reaction of isocyanate-containing compounds with alcohols to form a polyurethane. In many cases, solvents are used to control viscosity, which can increase considerably as rapid polymerization proceeds. Furthermore, a catalyst is often required to help the reaction reach completion within the time and temperature requirements of the specific application. Evaporation-based film formation In this mode of film formation, the molecular weight and the properties of the polymer to be used in a coating are fully developed before being dissolved in a solvent; pigments and additives are then added to develop the fully formulated coating. The liquid coating is applied to a substrate, and the film forms solely by solvent evaporation, which leaves behind a solid coating. Evaporation-based film formation is based on low solids content and large amounts of organic solvents. It is one of the fastest and simplest methods of film formation and was the basis of the nitrocellulose lacquers used in automotive production lines from the s to the s; it is still the mode of film formation of many spray paints. But it is a mode of film formation that, by itself, releases large quantities of solvent into the atmosphere. For this reason the use of lacquers as coatings that form films solely by solvent evaporation are often called has become severely limited by environmental legislation. Coalescence-based film formation If small polymer particles of 0. The polymer particles suspended in the water flow together, or coalesce, to form a film because of surface-mediated forces. If the polymer is below its T_g and is therefore in a rigid, glassy state, a small amount of coalescent a solvent that will plasticize the polymer and lower its effective T_g is added to the system to assist film formation. This coalescent later evaporates, leaving the solid polymer film. Coalescence-based film formation takes place mainly with latex polymers, but it also occurs with systems in which the polymer particles are dispersed in an organic solvent. However, limitations on the use of organic solvents has made water the predominant carrier solvent. Other reactions may occur during the melting and fusing processes, but the predominant film-formation reaction is the fusing, or coalescence, of the particles. Pigments Pigments are insoluble particulate materials that provide colour, opacity, gloss control, rheological control, and certain functions such as corrosion inhibition or magnetic moment. They also reduce the cost of coatings by acting as a volume filler. Pigments are used as fine particles ranging in size from 0. Composition ranges from carbon black to sand. White pigments Pigments that contribute light-scattering properties to coatings are generally known as white, or hiding, pigments. They act by scattering all wavelengths of light, owing to their relatively high refractive

index, so that they are perceived as white by the human eye. They are known as hiding pigments because the scattering of light reduces the probability that light will penetrate through a pigmented film to the substrate. A paint film of sufficient thickness and concentration of light-scattering pigment is truly opaque, hiding the substrate. The whiteness and opacity contributed by this class of pigments make them among the most extensively used pigments for coatings. The most widely used white pigment is the crystal form of titanium dioxide TiO_2 known as rutile. Rutile has the highest index of refraction 2. Another crystal form of TiO_2 , anatase, is sometimes used in coatings, but its lower index of refraction 2. Furthermore, surface-treated TiO_2 in its rutile form yields coatings that are more durable to exterior exposure than are equivalent anatase pigments. TiO_2 pigments are used in very high volume worldwide, especially in the so-called trade sales market, which includes retail, architectural, and contractor markets. In these applications, light, pastel, and white coatings predominate—thus the demand for TiO_2 . Its commercial use actually stopped much earlier, because of its low index of refraction 1. Nevertheless, the presence of old, peeling paint containing white lead pigment continues to be a health hazard in older buildings that are poorly maintained.

Colour pigments There are a large number of colour pigments, both organic and inorganic, that allow paint users to create films of almost all the colours in the visible spectrum. Colour pigments act by absorbing certain wavelengths of visible light and transmitting or scattering the other wavelengths. Some commonly used colour pigments are copper phthalocyanine-based greens and blues, quinacridone red, iron oxide red, iron oxide yellow, diarylide yellow, and perinone orange.

Filler, or extender, pigments Extensive use is made of pigments to occupy volume in coatings, enhancing their mechanical, thermal, and barrier properties as well as reducing their cost. They are most often inorganic materials that are naturally occurring or can be manufactured and put into pigmentary form at low cost. Examples of the materials used as filler pigments are talcs, calcium carbonate both manufactured and in its natural form, limestone, silicas, special sands for texture paints, micas, clays such as kaolin, and barytes the natural form of barium sulfate. The highest volume of filler pigments is employed in trade sales coatings for cost and property control and in industrial primer coatings for control of physical properties.

Specialty, functional, and other pigments This catchall class includes pigments that are very important but are used in relatively low volumes. Included are those specific materials which give unique optical properties to coatings, such as aluminum flake pigments for metallic automotive coatings, pearlescent pigments, fluorescent pigments, and other metallic pigments. Functional pigments are those which supply specialty chemical functions to a coating, including zinc oxide for mildew control, zinc chromate ZnCrO_4 for corrosion control in primers, antimony oxide Sb_2O_3 for fire-retardant coatings, and some compounds such as copper oxide CuO for barnacle control. Magnetic pigments, such as acicular iron oxide and chromium oxide pigments, are used in magnetic audio and video tapes for information storage.

Solvents and carrier liquids Since most polymer-based coatings are prepared and applied in liquid form, the solvents or carrier liquids are among the most important raw materials used in the coatings. In coatings classified as solvent-based, organic solvents are employed to dissolve the polymers and oligomers that will form the final cured coating. In addition, many of the polymers used in coatings have to be synthesized in organic solvents. In these systems, the solubility of the polymer in the solvent is necessary for the coating to be properly manufactured and applied, and here the solvent strength as well as the polymer solubility are key parameters. Other key properties of organic solvents are boiling point, relative evaporation rate, reactivity, and toxicity. Commonly used organic solvents include hexane and other aliphatic compounds that is, compounds with chainlike molecules; toluene, xylene, and other aromatic compounds with ring-shaped molecules; mineral spirits; methyl ethyl ketone; n-butyl acetate; t-butyl alcohol; and ethylene glycol.

Library of Congress Cataloging in Publication Data Main entry under title: Topics in surface chemistry. (IBM research symposia series) Proceedings of an international symposium held Sept. , , in the Federal.

Polymers are softer, which reduces the inflammation from strain mismatch between tissue and electrode surface. The reduced inflammatory reaction causes a decrease in thickness of the glial encapsulation which causes signal degeneration. For the best device integration in the body, it is important to get the stiffness between the two to be as similar as possible. To improve this interface, a conductive polymer coating smaller modulus than the electrode can be applied to the electrode surface which causes a gradient of mechanical properties to act as a mediator between the hard and soft surfaces. The added polymer coating reduces the stiffness of the electrode and allows for better integration of the electrode. The figure to the right shows a graph of how the modulus changes when integrating the polymer coating onto the electrode. Processing of conducting polymer coatings Another benefit of using conductive polymers as a coating for neural devices is the ease of synthesis and flexibility in processing. In the application for neural implants, electrochemical polymerization is used because of its ability to create thin films and the ease of synthesis. In the case of depositing a polymer coating onto electrode a common dopant used is poly styrene sulfonate or PSS because of its stability and biocompatibility. Specific conducting polymers being researched Polypyrrole One conducting polymer coating that has shown promising results for improving the performance of neural electrodes is polypyrrole PPy. Polypyrrole has great biocompatibility and conductive properties, which makes it a good option for the use in neural electrodes. PPy has been shown to have a good interaction with biological tissues. This is due to the boundary it creates between the hard electrode and the soft tissue. PPy has been shown to support cell adhesion and growth of a number of different cell types including primary neurons which is important in neural implants. The roughness on the electrode surface is directly related to an increased surface area increased neuron interface with electrode which increases the signal conduction. In one paper, polypyrrole PPy was doped with polystyrene sulfonate PSS to electrochemically deposit a polypyrrole coating on the electrode surface. The film was coated onto the electrode at different thickness, increasing the roughness. The study concluded that by adding a conductive polymer the impedance of the electrode system decreased, which increased the charge transfer making a more effective electrode. The ease and control of electrochemically depositing conducting coatings onto electrode surfaces makes it a very attractive surface modification for neural electrodes. Growth factors and pharmaceutical agents Neural progenitor cells NPCs The figure on the left shows the original silicon surface with a contact angle of The figure on the right shows the surface with the laminin that had a contact angle of Angles can be measured with a contact angle goniometer. Seeding implants with growth factors, such as neural progenitor cells NPCs , improves the brain-implant interface. NPCs are progenitor cells that have the ability to differentiate into neurons or cells found in the brain. By coating the implant with NPCs, it can reduce the foreign body reaction and improve biocompatibility. To attach the NPCs, prior surface modification of the implant is required; these modifications can be done via the immobilization of laminin an extracellular matrix derived protein on an implant, such as silicon. To verify the success of surface immobilization, Fourier transform infrared spectroscopy FTIR and an analysis of hydrophobicity can be used. The Fourier transform infrared spectroscopy can be used to characterize the chemical composition of the surface or a contact angle goniometer can be used to determine the contact angle of water to determine the hydrophobicity. A higher contact angle indicates higher hydrophobicity, showing successful modification of the surface via the laminin protein. The laminin immobilized surface promotes the attachment and growth of the NPCs and also allows for their differentiation, thereby reducing the glial response and foreign body response to the implant. NGF is a water-soluble protein that promotes the survival and differentiation of neurons. The addition of NGF into polymeric films can induce biological interactions without compromising the conductive properties or the morphology of the polymeric film. The properties of the release mechanism of the encapsulated DEX in the nanoparticles through the pore of the hydrogel network is pictured. Also, the amount of DEX that was loaded

into the nano-particles is demonstrated as well as the particle size range \approx nm Dexamethasone DEX is a glucocorticoid that is used as an anti-inflammatory and immunosuppressive agent. To quantify the amount of DEX that was successfully seeding into the nanoparticle, UV spectrophotometry can be used. In vitro tests have revealed that the impedance of the nanoparticle-loaded hydrogel-coated electrodes have similar impedance to the non-coated electrode bare gold. This shows that the nanoparticle-loaded hydrogel coating does not significantly hinder the electrical transport. The in vivo tests have shown that the impedance amplitude of the DEX-loaded electrodes was maintained at the same level it was at initially. However, non-coated electrodes had an impedance about 3 times greater than its original impedance 2 weeks earlier. This addition of anti-inflammatory drugs via nanoparticles indicates that this form of surface modification does not have a negative effect on the electrodes performance. Hydrogel surface modifications achieve this by significantly altering the hydrophilicity of the neural implant surface to one that is less favorable for protein adsorption.

In chemistry much of the interest in surface science has come from the obvious implications to such important and diverse fields as catalysis and corrosion. It takes little imagination to recognize that there are many other areas where advances in surface science can be brought to bear.

Surface Chemistry Wolfgang Pauli once stated that "the surface was invented by the devil," illustrating the complexity and difficulty of studying the surfaces of materials. This prompts a fundamental question: What is the surface of a material? The simplest definition is that the surface is the boundary at which the atoms that make up one material terminate and interface with the atoms of a new material. If the surface is considered to be just the outermost layer of atoms of a material, then it comprises on average only atoms per square centimeter 1 square centimeter equals 0. Surface chemistry is important in many critical chemical processes, such as enzymatic reactions at biological interfaces found in cell walls and membranes, in electronics at the surfaces and interfaces of microchips used in computers, and the heterogeneous catalysts found in the catalytic converter used for cleaning emissions in automobile exhausts. The development of modern surface chemistry did not begin until the early s as the tools needed to detect the small numbers of surface atoms relative to the bulk atoms predominately through electron-based spectroscopies became available. Almost thirty years later, the study of surface chemistry received another boost with the development of a new class of tools called scanned probe microscopies, which provide the ability to view the chemical changes of surfaces under different environmental conditions. Such tools were the first to allow for the direct three-dimensional mapping of positions of atoms at surfaces. These techniques changed the view of surfaces by offering scientists and engineers the ability to directly examine and modify surface chemistries at the atomic and molecular levels. For the first time many processes that occurred at surfaces and interfaces, such as catalytic reactions, could be directly probed. This revolution was so important that the inventors, German physicist Gerd Binnig and Swiss physicist Heinrich Rohrer , received the Nobel Prize in physics only five years later in This process occurs by coupling of the electronic states between the two surfaces. The STM utilizes the quantum mechanical phenomenon of tunneling to visualize the positions of atoms on surfaces. As the tip is scanned over the surface, electrons move between the tip and sample and a tunneling current is produced. This current is very sensitive to i . By attempting to maintain a constant current using a feedback loop monitored by a computer, the piezoelectric receives a signal from the computer to raise or lower the tip as it scans over the surface Figure 1. Plotting the changes in tip height and position produces a three-dimensional image of the surface, yielding the ability to view the locations of single atoms and to manipulate their atomic positions. Numerous areas of research have benefited from this technique, including semiconductor technology, growth of metals, and heterogeneous catalysis. Shown in Figure 2 is an atomic resolution image of sulfur atoms on a rhodium surface. Because of the crystalline nature of the Rh surface, the S atoms position themselves in an ordered arrangement as they bond to the metal. Similarly, for surfaces such as silicon, the atomic positions can be viewed. STM revealed for the first time the organization of the structure of atoms on silicon surfaces, having a significant impact on the design of semi-conductor devices. Imaging of semiconductors such as Si as a function of voltage between the tip and sample allows for direct visualization of the occupied and unoccupied states, a direct view into the chemistry of the surface atoms. Seeing the Rest of the World: Atomic Force Microscopy While STM gave researchers the ability to probe atomic scale events at metal and semiconducting surfaces, many of the materials of interest to surface scientists fall outside these classes of materials, such as the surfaces of oxides and biological materials that lack conductivity. AFM is a tool that provides similar surface mapping of materials as STM, but can be used for systems that are nonconductive as well. Quartz is an example of a naturally occurring piezoelectric. Piezoelectric materials are used to control the tip position in scanned probe microscopes because the changes in the piezoelectric dimensions can be controlled with sub-angstrom precision. In AFM, a sharp tip on a cantilever is placed in contact with a surface. The forces acting between the tip and surface cause the cantilever to bend. Using a feedback loop , this force is held fixed as the tip is scanned and "feels" its way over the surface, producing an image of the surface topography Figure

4. AFM measurements can be made in air or under liquids, which allows imaging of biologically important molecules and surfaces, within the nanoscale regime, under natural physiological conditions. AFM has also become an important tool in the measurement of surface properties ranging from basic structure to nanoscale mechanical properties such as friction, adhesion, and elasticity. The details of friction and adhesion are crucial at the nanoscale level, especially with the drive to move technology to even smaller length scales, leading to the development of microelectromechanical systems MEMS devices such as microscale motors, actuators, and switches. MEMS devices are currently used in critically important technologies such as shock sensors for the deployment of airbags in automobiles. The surfaces of these devices are typically covered with silicon dioxide glass; controlling the surface chemistry is essential in order to ensure the successful operation of the device. Studies of adhesion by AFM have led the way to probing local chemical forces at surfaces allowing for the fundamental molecular forces between molecules to be measured directly. Other unique aspects of surface chemistry that AFM has been used to explore include the imaging of liquid surfaces. Modification of the AFM tip with metals allows for the local electric field between the tip and sample to be monitored. Changes in the dielectric properties such as the large contrast between water and many solid surfaces allow for the position of liquid droplets to be observed and for the structures of thin films of water to be probed. Due to the ubiquitous nature of water, the details of the surface chemistry of water are of key concern in a wide range of systems including the chemistry occurring in the stratosphere where ozone-depleting chemical reactions occur on ice surfaces. The details of the local chemistry on surfaces at the nanoscale level, however, are very important to understanding surface properties. Optical spectroscopy and microscopy provide a means of chemically identifying materials; in conventional microscopy, however, the resolution limit is approximately half the wavelength of the light used to illuminate the sample. Thus, spatial resolutions are typically limited to approximately nanometers.

7. Near-field Scanning Optical Microscopy NSOM overcomes these limitations by "squeezing" the light through an aperture of approximately 50 nanometers. By bringing the tapered fiber to within about 10 nanometers of the sample, when the light is transmitted through the sample it is collected with a conventional microscope objective, spectroscopic as well as structural images of the materials on a surface can be observed. This approach has paved the way for single molecule spectroscopy and is opening new possibilities for the analysis of material properties at the nanometer scale. Technology is advancing into the infrared and microwave regions of the spectrum, allowing for the chemical composition and dielectric properties of materials to be probed with high spatial resolution. Figure 6 shows a near-field optical image of a polymer blend of polystyrene and polyethylacrylate, taken in the infrared region of the spectrum showing high spatial resolution spectroscopy.

Nanostructures on Surfaces The design of nanostructures on surfaces using scanned probe microscopies enables the custom design and manipulation of matter on the atomic and molecular level. An STM or AFM tip can be used as a "nanowriter," placing and pushing around atoms and molecules on surfaces to make organized structures. Single atom positioning heralded by American physicist Donald Eigler at IBM showed the way in which atoms could be placed in complex structures using an STM to carry and position atoms on a surface with high precision. Given the ability to write structures at this length scale, the entire Library of Congress could be written on the head of a pin. Although the timescale needed to write structures atom-by-atom makes this prohibitive as a general tool for large-scale lithography, the feasibility has been shown. This burgeoning area of nanotechnology has surface chemistry at its heart, as the detailed control of matter at the molecular level on surfaces is viewed as part of the next technological revolution. The generation of nanostructures with AFM using dip-pen and nanografting patterning methods has shown great utility in the writing of complex molecules onto surfaces for use in nanoscale devices and sensors. In dip-pen lithography an AFM tip "inked" with molecules is scanned along a surface in a controlled pattern. Under the appropriate conditions the molecules transfer from the tip to the surface, much as a fountain pen writes on a piece of paper. Nanografting provides another means by which structures may be prepared on surfaces. In nanografting, a background layer of alkanethiols on gold is initially formed as a support matrix. When this surface is imaged in a background solution of a different molecule than the matrix, as the AFM tip scans through the matrix molecules, they are scraped away mechanically removed and replaced by the new molecules present in solution. Figure 8. This methodology has been successful in creating structures ranging

from a few nanometers to tens of nanometers in dimension. Both of these approaches and modifications thereof are rapidly advancing the methodology of "nanowriting. Batteas Bibliography Binnig, G. Scanning Probe Microscopy and Spectroscopy: Theory, Techniques and Applications. Critical Assessment and Research Needs. Theory, Instrumentation and Applications. Introduction to Surface Chemistry. Cite this article Pick a style below, and copy the text for your bibliography.

Chapter 4 : Chemistry Topics/Surface Chemistry: TestprepKart

Surface chemistry is the study of chemical reactions at surfaces and interfaces. Appreciating how molecules and atoms interact with surfaces and with each other while on surfaces is key to understanding desirable chemical reactions, such as in heterogeneous catalysis, and also those that are undesirable, such as in corrosion chemistry.

Surface science Save STM image of a quinacridone adsorbate. The self-assembled supramolecular chains of the organic semiconductor are adsorbed on a graphite surface. Surface science is the study of physical and chemical phenomena that occur at the interface of two phases, including solid–liquid interfaces, solid–gas interfaces, solid–vacuum interfaces, and liquid–gas interfaces. It includes the fields of surface chemistry and surface physics. The science encompasses concepts such as heterogeneous catalysis, semiconductor device fabrication, fuel cells, self-assembled monolayers, and adhesives. Surface science is closely related to interface and colloid science. The methods are different. In addition, interface and colloid science studies macroscopic phenomena that occur in heterogeneous systems due to peculiarities of interfaces.

History The field of surface chemistry started with heterogeneous catalysis pioneered by Paul Sabatier on hydrogenation and Fritz Haber on the Haber process. The Langmuir adsorption equation is used to model monolayer adsorption where all surface adsorption sites have the same affinity for the adsorbing species. Gerhard Ertl in described for the first time the adsorption of hydrogen on a palladium surface using a novel technique called LEED.

Surface chemistry Surface chemistry can be roughly defined as the study of chemical reactions at interfaces. It is closely related to surface engineering, which aims at modifying the chemical composition of a surface by incorporation of selected elements or functional groups that produce various desired effects or improvements in the properties of the surface or interface. Surface science is of particular importance to the fields of heterogeneous catalysis, electrochemistry, and geochemistry.

Catalysis The adhesion of gas or liquid molecules to the surface is known as adsorption. However, it is difficult to study these phenomena in real catalyst particles, which have complex structures. Instead, well-defined single crystal surfaces of catalytically active materials such as platinum are often used as model catalysts. Multi-component materials systems are used to study interactions between catalytically active metal particles and supporting oxides; these are produced by growing ultra-thin films or particles on a single crystal surface. Results can be fed into chemical models or used toward the rational design of new catalysts. Reaction mechanisms can also be clarified due to the atomic-scale precision of surface science measurements. Adsorption and desorption events can be studied at atomically flat single crystal surfaces as a function of applied bias, time, and solution conditions using scanning probe microscopy [11] and surface X-ray scattering.

Geochemistry Geologic phenomena such as iron cycling and soil contamination are controlled by the interfaces between minerals and their environment. The atomic-scale structure and chemical properties of mineral-solution interfaces are studied using in situ synchrotron X-ray techniques such as X-ray reflectivity, X-ray standing waves, and X-ray absorption spectroscopy as well as scanning probe microscopy. For example, studies of heavy metal or actinide adsorption onto mineral surfaces reveal molecular-scale details of adsorption, enabling more accurate predictions of how these contaminants travel through soils[13] or disrupt natural dissolution-precipitation cycles. It overlaps with surface chemistry. Some of the things investigated by surface physics include friction, surface states, surface diffusion, surface reconstruction, surface phonons and plasmons, epitaxy and surface enhanced Raman scattering, the emission and tunneling of electrons, spintronics, and the self-assembly of nanostructures on surfaces. In a confined liquid, defined by geometric constraints on a nanoscopic scale, most molecules sense some surface effects, which can result in physical properties grossly deviating from those of the bulk liquid.

Analysis techniques The study and analysis of surfaces involves both physical and chemical analysis techniques. These include X-ray photoelectron spectroscopy, Auger electron spectroscopy, low-energy electron diffraction, electron energy loss spectroscopy, thermal desorption spectroscopy, ion scattering spectroscopy, secondary ion mass spectrometry, dual polarization interferometry, and other surface analysis methods included in the list of materials analysis methods. Many of these techniques require vacuum as they rely on the detection of electrons or ions emitted from the surface under study. This is found

by an order of magnitude estimate for the number specific surface area of materials and the impingement rate formula from the kinetic theory of gases. Purely optical techniques can be used to study interfaces under a wide variety of conditions. Reflection-absorption infrared, dual polarisation interferometry, surface enhanced Raman and sum frequency generation spectroscopies can be used to probe solid-vacuum as well as solid-gas, solid-liquid, and liquid-gas surfaces. Multi-Parametric Surface Plasmon Resonance works in solid-gas, solid-liquid, liquid-gas surfaces and can detect even subnanometer layers. Dual Polarization Interferometry is used to quantify the order and disruption in birefringent thin films. X-ray scattering and spectroscopy techniques are also used to characterize surfaces and interfaces. While some of these measurements can be performed using laboratory X-ray sources, many require the high intensity and energy tunability of synchrotron radiation. Surface-extended X-ray absorption fine structure SEXAFS measurements reveal the coordination structure and chemical state of adsorbates. X-ray photoelectron spectroscopy XPS is a standard tool for measuring the chemical states of surface species and for detecting the presence of surface contamination. Surface sensitivity is achieved by detecting photoelectrons with kinetic energies of about eV, which have corresponding inelastic mean free paths of only a few nanometers. This technique has been extended to operate at near-ambient pressures ambient pressure XPS, AP-XPS to probe more realistic gas-solid and liquid-solid interfaces. These microscopies have considerably increased the ability and desire of surface scientists to measure the physical structure of many surfaces. For example, they make it possible to follow reactions at the solid-gas interface in real space, if those proceed on a time scale accessible by the instrument.

Chapter 5 : Surface Chemistry MCQs | Questions – Paper 2

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Chapter 6 : An Introduction to Surface Chemistry

The role played by surface phenomena in the overall behavior of a material has been a subject for speculation for a long time, but only during the last decade or so have experimental and theor-

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Surface chemistry can be roughly defined as the study of chemical reactions at interfaces. It is closely related to surface engineering, which aims at modifying the chemical composition of a surface by incorporation of selected elements or functional groups that produce various desired effects or improvements in the properties of the surface or interface.

Chapter 8 : Surface chemistry of neural implants | Revolv

surface chemistry, study of chemical reactions in which the reactants are first adsorbed onto a surface medium (see adsorption) that then acts as a catalyst for the reaction; after the reaction the products are desorbed and the surface is left unchanged. Since the entire reaction takes place on the surface, the amount of surface area of.

Chapter 9 : CBSE class 12th Chemistry | Surface Chemistry

This Research Topic "Surface Chemistry and Materials Design in Lithium-sulfur Batteries" is therefore launched aiming at the forefront research in this exciting area with widespread topics, ranging from sulfur trapping chemistry, novel structures, materials design, electrolyte, separator, lithium metal protection, the interfaces between.