Al-Karkh University of Science
College of Energy and Environment Sciences
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Nanotechnology

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First lecture

Introduction

Nanotechnology (NT) is an emerging multidisciplinary technique that involves application based on the synthesis of molecules in Nano-scale size range. **Nanotechnology** is also seen as new and fast emerging filed that involes the manufacture, processing and application of structure, device and system by controlling shape and size in nanometer scale. The concept of nanotechnology is driven from Greek word nano (meaning dwarf).The Nano-particle are defined as a discrete entity that has dimentions of the order of 100 nm or less . It is the small size in combintion with the chemical compostion and surface that gives the nano-particales their unique features . The alterations in physical properties serve to enhance versatility and efficancy in product devlopment,resulting in more effective industrial and medical applications . As a result of the widespread use of nanotechnology and nano-materials , these particals find their way into the enviroment . Therfore , a focus on the source of nano-particles in the environment and their effects is included. This review concertrete on the recent information about analytical development. It also focuses on the applications of nanotechnology in enviroonment, especially in the area of air and water purifications .

History of nanotechnology

The history of nanotechnology traces the devlopment of the concepts and experimental work falling under the broad category of nanotechnology . Although nanotechnology is a relatively recent development in scientific research , the devlopment of its central conceps happand over a longer period of time . The emergence of nanotechnology in the 1980 was caused by the convergence experimental advances such as the invetation of the scanning tunneling microscope (STM) in 1981 and the discovery of fullerenes in 1985 , with the elucidation and popularization of a concepual framework for the goals of nanotechnology beginning with the 1986 publication of the book Engines of Creation . The fieldwas subject to growing public awareness and controversy in the early 2000 , with prominent debates about both its potential implications as well as the feasibility of the molecular nanotechnology , and with government moving to promote and found research into nanotechnology . The early 2000 also saw otechnologh , although these were limited to bulk applications of nonomaterials rether than the tranaformative applications visioned by the filed

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Sources of nanoparticles in the environment

Nanoparticles are dispersed in the environment (air , water and soil) naturally or from unnturally pollution sources that include industrial and combustion processes . The following table showes that .

The main sources of nanomaterials in the environment

Source	Natural source of origin	Industrial source of origin	Engineering designed nanoparticles
Air	1 – Volcanic explosion 2 – Biological processes 3 – Nuclear processes	1- Burn processes 2 – Industrial emissions 3- manufacturing processes	1 – Nanotechnology
Water	1 – Metal sulfide nanoparticles 2 – Manganese oxide	1 – Precipitation from the atmosphere	1 – Diffusion of nanoparticle durnig manfactures and use
Soil	1 – Nanoscale metals 2 - Bio minerals 3 - Pools of natural organic matter	1 - Precipitation from the atmosphere	1- Diffusion of nanoparticle durnig manfactures&use

Difference between composite and nanomaterials

Compsite materials

Compsite materials are a mixture of two or more materials , each of which has different properties from the other . When mixed with each other, We get a new material that has properties separate in terms of strengh, stiffness , resistance to fracture and craching.

Composite materials are the best alternative to metals in industrial applications. The reason for this is because they have the same strengh as metals, plus,its lighter.

Composite materials cosist of two basic materials:

- **Matrix**
- **Rinforcement material**

The rinforcement material is in the form of fibers or particles that make the composite materials more resistant to cracking or fracture. The matrix works to protect rinforcement material from external damage.

A composite materials are classified according to the type of matrix into three types:

1 – **Polymer matrix composites:**

The matrix is this type of plastic and when the reinforcement material is glass fiber then the composite material is used in the manfaucture of car glass.

2 – **Metal matrix composites**:

Titanium, copper and iron are used as matrix for this type of composiete material.

3 – **Ceramic matrix composites:**

Borosilicate glass is used in some parts of aircraft engines, because of itsablility to withstand high temperatures as well as its light weght.

Nanomaterial

Nanomaterial are made of nanoparticales, whether ceramic or metals, ther are much better in their properties than those of larger nanoscale counterparts, such as composite materials.

The resoan for the great change in the properties of nanomaterials for composite materials is:

1 – Increase an proportional in area.

2 – Increase in chemical activity.

3 – Improvement in mechanical properties.

4- Improvement in physical properties.

5 - Improvement in optical properties, such as TV screens, computers, and phones.

6 – Increase in ability and effectiveness of magnetic properties.

7 – Increase in its ability to conduct electrical current.

8 – Improving biological properties by pentrating biological barriers and barriers.

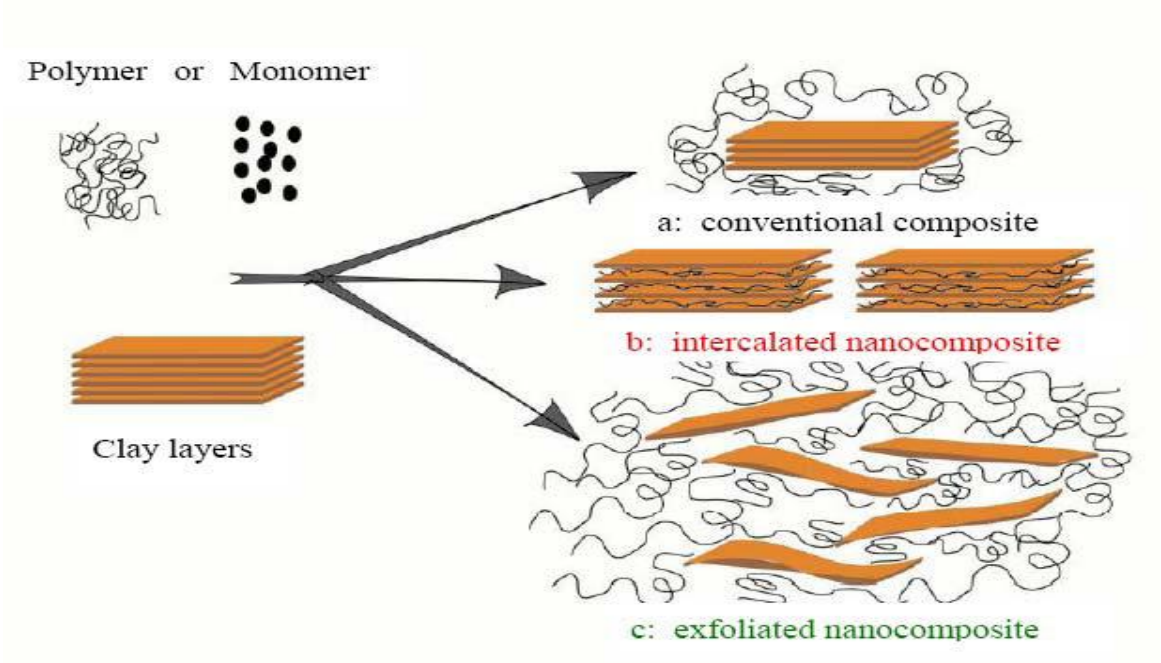
Second lecture

Types of composite of structure by TEM & SEM

Three main types of composites may be obtained when a **Rinforcement material** (layered clay) is associated with a **matrix** (polymer). These primarily depend on the method of preparation and the nature of components used (layered silicates, organic cation and polymer matrix)

Transsmision electron microscopy (TEM) & **scan electron microscopy (SEM)** is therefore used to determine This conventional (Traditional) composite (composite materials) and nanocomposite morphology (Intercalated & Exofilated nanocomposites). In addition to these two defined structures, both intercalation and partial exfoliation result in a broadening of the diffraction peak.

The follwing diagram and images show the types of compostions of nanoscale and composite material with a TEM & SEM .



a - conventional (Traditional) composite

b - Intercalated nanocomposite

c - Exofilated nanocomposite

Using vegetable oil as a renewable energy source to obtain nanomaterials :

Plants (vegetables) considered one of the raw materials sources to obtain renewable energy through vegetables oil, and that by using them as surfactants for some materials in industry and other uses to produce renwable energy.

Among the surfactants prepared from vegetables are fatty amides (F A) , which organic materials that penetrate the layers of the substance that mix with it and increase the distance between the material layers (d)and turn it into a nanocomposite. The material is test by SEM, TEM and XRD.

To calculate the distance (d) the Bragg law is used:

X-Ray diffraction study was carried out, this method is very common techniques to analyze the composition of the materials. In 1912, William Lawrence Bragg and his father William Henry Bragg formulated

Bragg's law $n\lambda=2d\sin\theta$

λ= wavelength of which is = 0.15406 nm

n= integer represents rank diffraction peak

d= distance between the material layers, nm

θ= **scattering** angle

which is the significant equation to build the relation of diffraction. When the wavelength (**λ**) of radiation is close to the spacing (**d)** between the atoms, the atoms can be considered as the diffraction grating and have the constructive and destructive interference of the scattering which is shown in Figure .

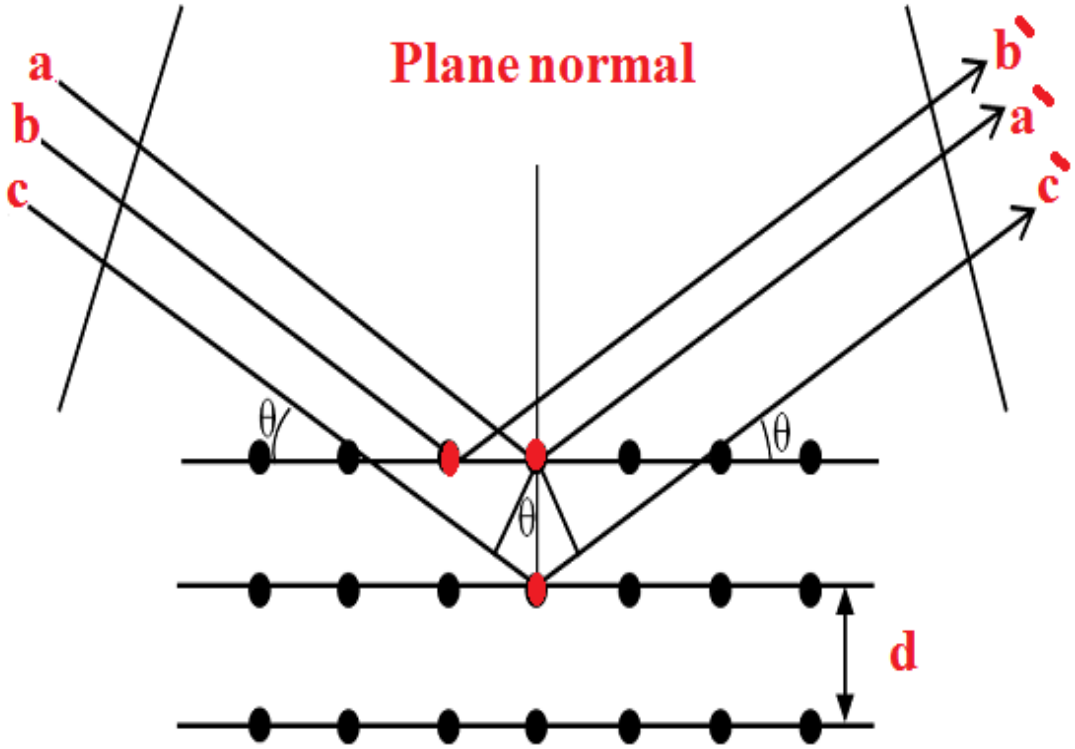


Figure : Clearly measured incident angle by X-ray diffraction from a layered structure

X-ray diffraction technique was used to measure the interlayer distance of the silicate layers of the clay and modified silicate layers with FA cation.

The incident beam a and b have the same incident angle and travel distance which causes the constructive interference.The incident beam c moves in phase with a and b if the extra travel distance $2d\sin\theta$ is equal to the integral number of wavelength , or it results in destructive interference when out of phase.

The constituents of an X-Ray diffractometer are the source, sample, mono-chromater, detector and output device. In the hot cathode tube, the electrons are emitted from tungsten filament when heated, and travel through the electron field to impinge anode. There are two phenomena that happen when the impingement occurs. One is the inelastic collision when the partial kinetic energy of electron transfers into the continuous spectrum which is also called white radiation. Another is the characteristic spectrum which is caused by the excitation of the inner-shell electron with collision and meanwhile, the outer- shell electron fills the inner-shell and releases energy between the energy levels in X-Ray form. The source of the X-Ray diffractometer has a characteristic radiation, usually using Cu Kα and filtered by nickel as the mono-chromater, the wavelength of which is (λ= 0.15406 nm).

Cement nanocomposites

Third lecture

Introduction

Cement consider a composite materials, is the most widely used construction materials they are rsistant to water , easily formed into vairous shapes and sizes , thr cheapest and readily available every where. One of the main types of portland cement is salt- resistant portland cement (rpc), the weighted percentage (% wt) components are in accordance with the British specifications as table shows:

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Table: The main and secondary components of resistant cement rpc)
(

Description	Formula	% wt
Tricalcium silicate (C_3S)	$3CaO\ SiO_2$	58
Dicalcium silicate (C_2S)	$2CaO\ SiO_2$	17
Tricalcium aluminate(C_3A)	$3CaO\ Al_2O_3$	3
Tetacalcium aluminoferrite (C_4AF)	$4CaO\ Al_2O_3Fe_2O_3$	14
Sulfur trioxide	SO_3	2.56
Silicon Oxide (Silica)	SiO_2	21.0
Ferric Oxide	Fe_2O_3	4.65
Aluminum Oxide (Alumuna)	Al_2O_3	4.07
Magnesum Oxide	MgO	0.92
Free lime	CaO	63.8

Because the resistant cement and concrete contains pores, which leads to a weakening in the mechanical engineering properties , to contain the cement, these disadvantages were directed to appling the production of nano-cement materials can lead improvements in civil infrastructure because the mechanical strength and life of concrete structures are determined by the microstructure and the by the mass transfer in nanoscale .Some ressearchers have also studied the propertties of cement and concrete

materials with other nano-materials reinforcement , such as nano-Al_2O_3 , nano-ZnO_2, nano-Fe_2O_3,nano-CuO, nano- ZrO_2 and nano-clay(organo-modified-montmorillonites).

Recent studies have shown that ternary silica (nano-silica) particles (NS_t) with an average diameter of about 14 nm , used as an additive to rpc_l can improve its mechanical properties , the structure , morphology and compressive strength of the synthesized nano- rpc_l were studied. NS_t was used to prepare new rpc_l / NS_t nano-composite

Preparation of nano- cement (rpc_l/ternary silica)

The designed amount of rpc_l / NS_t was prepared by an mixier on a two - roll mill , then we put the sample in an Enlish mechanical vibrator type BIRMIHGHAM , then we put the mixture in an English electric oven type GALLENHAMB at temperture of (950 – 1000 C) and for a period of time up to 40 minutes and then we will process the immediately cooling, then we use a German type Sartorius sensor to weigh the samples . The amount of rpc_l and NS_t used this study are listed in Table

Table : The amounts of rpc_l and NS_t in the nano- cement

Sample identity	Weight of rpc_l , g	Weight of NS_t , g
rpc_l add 0	50.0	0.0
rpc_l add 1	47.5	2.5
rpc_l add 2	45.0	5.0
rpc_l add 3	42.5	7.5
rpc_l add 4	40.0	10.0
rpc_l add 5	37.5	12.5

add 0, add 1, add 2, add 3, add 4 and add 5 = 0, 5 , 10, 15, 20 and 25% weight of NS_t , respectively

Characterization

X-ray diffraction measurements

X-ray diffraction technique was used to measure the interlayer distance of the rpc_l , NS_t and rpc_l / NS_t . It was also used to measure the NS_t distribution of in the rpc_l matrix. Depending on the measurements of the 2Ø through the XRD device , when adding 5% to 25% by weight from NS_t to rpc_l found when adding 10% gives the largest distance between the particals rpc_l .

Scan electron microscopy (SEM)

SEM images of microstructure (5 micrometer) are shown in figures (1 , 2) . the image in figures (1) show locally resistant portland cement (rpc_l) , the particles appear to be conglomertad and it has many pores between the particles . The image in figures (2) show locally resistant portland cement (rpc_l) mixed with 10% wt from ternary silica particles (NS_t), where it appears through the image that the pores were filled with the mixture became homogeneous nanoparticles .

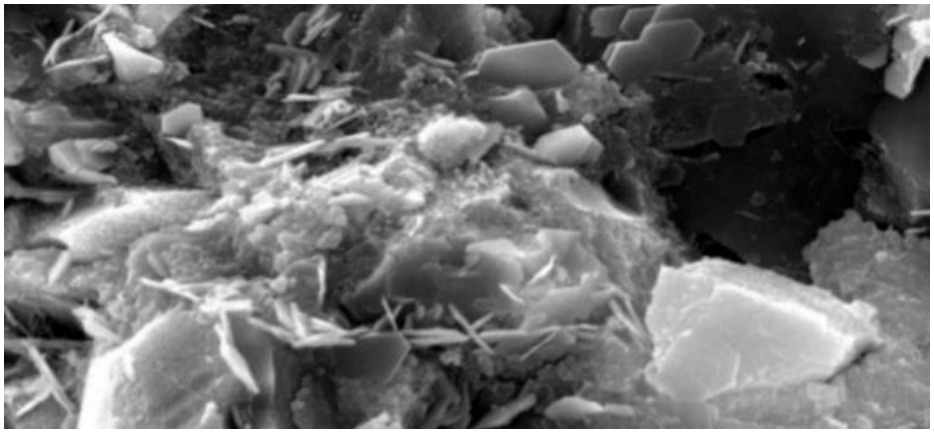

Figure 1: SEM image of microstructure of the patterns of rpc_l

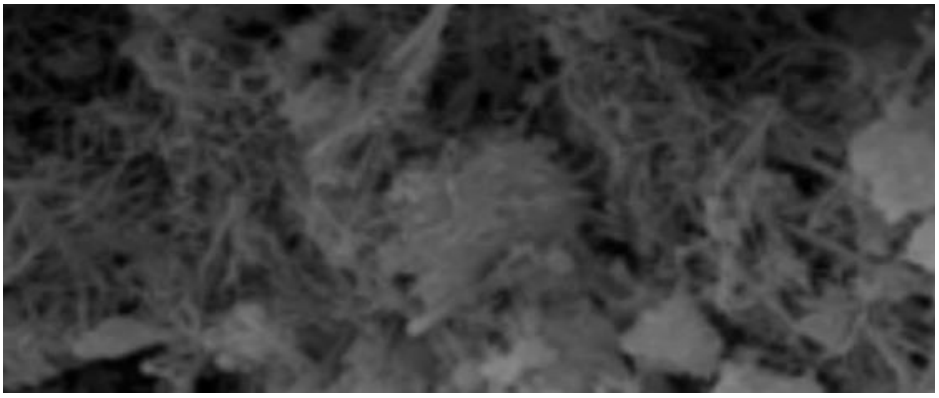

Figure 2: SEM image of microstructure of the patterns of rpc_l / NS_t

Conclusions, New nanocement prepared by adding ternary silica (NS_t) to locally resistant portland cement (rpc_l) . Through the diagnosis by the XRD and SEM divices , it was found that the ratio of adding the NS_t to the rpc_l is 10 wt% . Through the diagnosis , it was observed that the percentage increased from 10 wt% , there are congiomerates in the cement mixture .This percentage leads to improve the compressive strength ,other mechanical properties , a delay occurrence of fatigue and carbonization of the concrete mixture because of the occurrence of better morphology and full of pores , this shown by SEM in image 2 .

Four lecture

Preparation of ternary silica particles (Nano-silica)

The main structure of ternary silica particle is silicon oxide (SiO_2) , where these silicates dissolve in HCl acid and in the presence of NH_4Cl that breaks down the silica gel as it is formed . Thus, silica is allowed to precipitate quickly by heating for thirty minutes on a water bath, then precipitate is filtered and washed with HCl acid and with water, it is burend in an electric oven with a degree of (950 – 1000 ^oC) in a_ platinum dish for 45 minutes, then the dish is cooled and weighed , where the weight reoresents the sum of silica and impurities . The determine the pure silica , the silica is evaporated in the from of SiF_2 using H_2SO_4 acid . and the precipitate is burned with an (1150 – 1200

^{o}C) , then cooled and weighed . Pure silica is converted into elementary particles of microscopic by a thermal flame and the result of this process is the primary for ternary silica particles ,these particles tend to agglomerate togther to give secondary particles and then agglomerate to give chains of ternary silica particles . The main reason for the strong tendency for the agglomeration of primary silica particales (zero- dimensionalis silica) the presence of polar hydroxyl group (OH^{-}) on the surface of their particales , this leads to strong hydrogen bonds between silica particales (the bonds are between a hydrogen atom of a a hydroxyl group in the first particle with an oxygen atom in the second particle) so when zero (liquid – silica) mixtures are prepared for the puroose of their use there must be extreme heating and stirring the liquid mixture for a long period of time , then the three- dimensional structure formed breaks down and the large silica conglomerates are separated into smallar ones and figure shows that

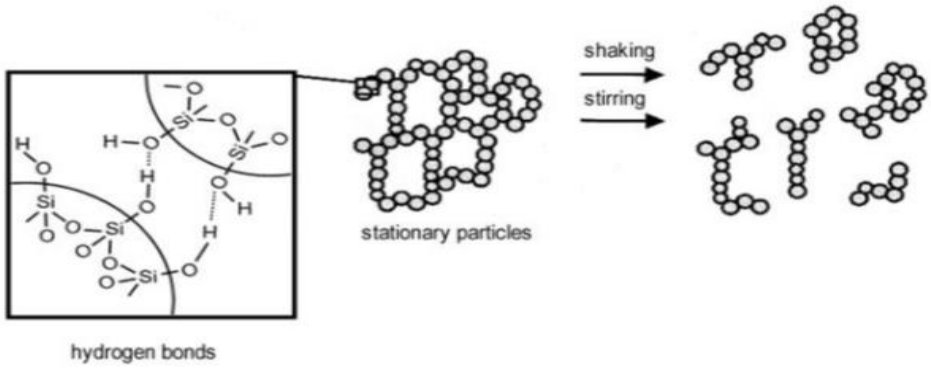

Figure: shows converting large conglomerates of triple silica into smaller conglomerates

Methodes of preparing nanomaterials

Introduction

Nanomaterials are nanochemical materials that are used with high quality in many industrial applications such as communications, electrons and midical filds becouse they contain many physical and chemical properties, and they are

prepared in several ways all in common by reling on the atomic scale, i.e. one atom towards another atom to obtain desired results, and whenever the size scale for the mass of the substance differd, the chemical activity dieeered in the sense that the smaller the scale, the higher the chemical activity of the substance. **Methodes of preparing nanomaterials :**

1 – Physical methods
2 – Chemical methods
A – Vaper- state reactions

B – Interaction in a liquid medium

3 - Mechanical methods
A – Mechanical composition:
B- The first monitoring and vitrification process
C- Strong diformation techniques
D- Grinding method
E - Scrubbing method
F – Electrochemical method
G- Laser so that laser beam
H – Ventilation method

Five lecture

1 – Physical methods

It is prepared starting from the vaper state of the substance by heating the material or by throwing it with a beams of electron or thermaL dislving it using laser beams, then the vapor is cooled by string it with a neutral gas to become more saturated and then it is placed on a cold surface quickly to avoid the occurrence of crystalline construction , then materials are prepared using nanoscale, using laser.

2 – Chemical methods

A – Vaper- state reactions:

Vaper enters, the thermal to be prepared in the CVD reactor, the material particals are mixed on a basic surface at a certain tempature and interact with other gases to form a solid strip on the surface of the base, and this method is used to prepare such as quasi- monemers.

B – Interaction in a liquid medium

Water or organic liquids are the most used, and nanomaterials are prepared by changing the chemical-physicalbalance conditions or hydrolsis to obtain spherical particales that can be

controlled in their dimensions, or through double or double chemical preciptation reactions analysis with water to obtain spherical particles whose dimentions can be controlled, techniquos by using Sol gel using colloidail solutions at low temperatures.

3 - Mechanical methods

A – Mechanical composition:

By crushing a material consisting of micrometeric particales from (1 to 30) into several mixtures and mixing them. Bulky materials of several tons.

B- The first monitoring and vitrification process:

By converting the atomic material into a huge piece, through two stage of melting the metal powder to form it after cooling.

C- Strong diformation techniques ;

Through by strongly deforming a crystalline material such as metal or porcelain in order to improve the hardess and ductility properties of the materials.

D- Grinding method :

It is used to produce nano-materials in powder form, where the base material is exposed to a very high energy . Grinding them with steel balls that move vibratory, planetary or vertical, and the size of the nanomaterials that are fabricated ranges from 3 to 25 nm.

E - Scrubbing method :

By placing very thin silicone strips in chemicals such as HF, and rubbing the silicone strips to obtain .
On the silicon particales slides, put these slide in a solution such as isopropanal and then in an ultrasound machine to drop the particles into solution.

F – Electrochemical method :

By placing the silicon slide at the anode and the polycarbonate slide at the negative electrode in a chemical solution , and exposing the slides to an electric.

G- Laser so that laser beam :

By exposing the material to a very high energy pulsed laser so that the laser beam interacts with the target, which leads to the volatilization of the particales of the substance and the formation of the plasma that are deposited on the and forming a thin film.

H – Ventilation method :

By exposing the material to a very low pressure vacuum thin film . And with a cold base , they are exposed to a magnitic field, which leads to the removel of the particales of the substance and deppositing them in the base , forming a thin film.

TheTutorial of previous lectures in NT

Q1/ What are the main soureces of nanoparticales in air (natural, industrial and engeneering designed)

Q2/ What is the difference in properties between nanoparticles and conventional composites (explain eight differences)

Q3/ Explain with the example of using vegetable oils as ernewable energy sources to obtain nanomaterials.

Q4/ Write in detail the method of preparing the nanocement by adding ternary silica to the cement.

Q5/ Write in detail the method of preparing the nano- ternary silica from primary silica particales (Zero- dimensionalis silica).

Q6/ What are the main methods for preparing nanomaterials, have been detalid on the physical methods of preparation.

Q7/ Write in detail a method for preparing a nanomaterial so that the nanomaterials are in the form of a thin film. Q8/ Whate are the mechanical methods for preparing nanomaterials , then write in detail the method of grinding.

Seven lecture

Properties of nanomaterials

The properties of materials change very significatly according to their nanoscale components, so the compounds composed of stronger granules in the nanoscale , whether ceramics or minerals, are much than their counterparts in the larger size, for example about (10) times stiffer than themetal (grain size foe example). The is 7 mineral is the size of ordinary grains, the size of grains is measured in hundreds of nanometers, and this major in the propertes of materials in the nanoscale is caused by the following :

1 – Relative increase in area:

Nanomaterials have a larger surface area when compared to the same mass of the material produced in the larger space, and this makes the materials more chemically active and affects their strength or electrical properties.Sometimes the inert materials in the large space may be active when they are produced in the nanosphere, that is , when they are reduced.

The particales that make up matter, a very large percentage of the atoms are percent on the surface compared to those inside. Particales with a size of 30 25 nm are percent only 5 % of

them on the surface, the on surface, while others with a size of 10 nm are percent 20% of which are on the surface , and a volume of 3N , 50% of which are percent on the surface , and since the chemical reactions occuring at the surface , legal materials are more energetic than their counterparts for the most part.

2- Quantitaive effect:

Quantitative influences begain to control the behavior of matter in the lower end seall aylgill ,especially space , in the nanoscale affecting the electrical , magnetic and optical properties of materials.

The following are some of the properties of nanomaterials :

Mechanical properties :

The mechanical properties come on top of the properties that benefit from from the reduction in the size of the grains of the material and the presence of huge numbers of atoms on the faces of its outer surface, as the hardness of metallic materials and their alloys increases , and their resistance to facing stresses and the loads on them increases .

Formability and bearing stresses that not durability, available , and this means the creation of new types of these materials.

Chemical activity :

The chemical activity of nanomaterials increases with the presence of huge numbers of atoms of substance on the faces of their external surfaces, where they act as catlysts that intercat strongly with toxic gases , which filters them to play the most important role in reducing environmental pollution , and fuel cells are one of the low-cost applications of catalysts nanoparticles, and one of the important sources of new and clean energy.

Physical properties :

The materials melting point values are affected by the erduction of the dimensions of its grains. The melting point of gold in its normal size reaches 1064 degrees, its weight to about 1.35 nm . 500 degrees after its grains are reduced to.

Optical properties :

It is surprising and exciting that the color gold-golden yellow- changes to a transparent of natural color when it grains are reduced to less than 20 nm , and its colors change from green to orange and then red with the increase in their sizes, and this feature enables us to make high- resolution screens high constant and clarity of colors, such as modern TV screens, computers and mobile phones.

Magnetic properties:

The smaller the grains materials and the doubling of the atoms on their external surfaces , the more powerful and effective their magnatic power , which enables us to use them in large electrical genertors , ship motors,the

manufactureof high – precision analysis devices, analyzers, and magnetic resonance imaging.

Electrical properties :

The smallness of the materials particals sizes to less than 100 nm increases their ablity to conduct electrical current, which enables us to use these materials in the micro-sensors and elctronic chips.

Biological properties:

Increasing the penetration ability of nanometerials to penetarate biological barriers and barriers, and improve compatiblity and biocompaliblity , which facilitates the dilivary of drugs and therapeutic drugs to the affeacted part through membranes and vessels bloody.

H.W

Q1 : What is the main property that improves the properties of nanomaterials, with the reasons being mentioned in detail.

Q2 : Chemical activity of the important properties of nanomaterials explain the following :

A – Increase the chemical activity of nanomaterials.

B – The chemical activity reduces environmental pollution .

Eight lecture

Nano - Mechanics

Nanomechanics : is one of the of nanotechnology , which is concrned with the branches study of mechanical properties, of elasticity, heat and motion of natural

physical systems with nanometer scales. The science of nanomechanics appeared at the meeting point of all the sciences of classical mechanics , solid state physics, and statisical mechanices, materials, and quantum chemistry. As a branch of nanotechnology , nanomechanics provides a scientific basis for nanotechnology.

Hence, thescience nanomechanics is one of the branches of nanoscinence that deals with the study and application of basic mechanical properties (from elasticity , heat and movement) to physical systems nanometer dimentions.

Nanomechenics is often reviewed as a discipline from the science of nanotechnology , and for an illustration as an applied area focusing on the mechanical properties of nanostructures .

Nanosystems are those systems with nanoscale components, nanotubes, including carbon nanotubes and boron nitride nanotubes (BNNTs).

Nanofilms, nanoparticles/nanomaterals liquids or fluids continaining dispersad nanoparticals.

And as one of the basic sciences, the scince of nanomechanices is based on some experimental principles (basic notes), including :

1 – Principles of general mechanics

2 – Special principles stemming from the smallness of the physical sizes for designated purposes for research study.

H.W

- And as one of the basic sciences, the scince of nanomechanices is based on some experimental principles, what are the principles upon which the science of nanomechannics relied.

Nine lecture

Nano- chemistry

When we combine nanotechnology and chimistry , we get something called nanochemistry, which is the technique of studying and working on the smallest parts of the atom with the goal of engineering very small materials with the smallness of the number nanochemistry, and chemists and nanoparticales use a of different ways to prepare and collect small parts materialexhibit unique magnetic, the of electronic, optical, chemical and mechanical behaviors, due to its extremely small size.

Nanotechnology in chemistry represents uncommon appoaches in building devices by focusing on designing on small atoms, to enjoy accurate molecular scale . This process is based on studying the synthesis and characterization of materials on the nanoscale, and foucsing . How atoms interact and behave , and how they ,can be controlled and manipulated into effects. And chemical reactions at the level of the atom.

Concentration of nanochemistry or nanotechnologyin chemistry , also,the process of assembling single atoms in larger molecules and the ersulting behavior of doing so, and this prcess is one of the biggest benefits of nanochemistry . as it paves the way for the creation of new materials and products , especially as it used a wide range of chemical , physical , materials on science, engineering , and biological applications.

The role of nanotechnology in chemistry

Nanotechnology is a new concept that helps to mix chemistry with several essential factorsin our life such as communcations, electronics, photonics, and space engineering, transportation and medicene.

The importance of nanochemistry

The importance of this technique stems from its great influence on our daily life and the things it can offer us, which we could not imagine a few decades ago.

We can summarize the benefits of nanotechnology in chemistry, its impact, or what you might like to call it between them via the following points :

1 – Create computers that are stronger, faster , and energy. Smaller in size and use less help develop batteries that will last long time production.

2 – Of more effective and fast medical diagnostic tools, and development of lab on chip to provide accurate and direct medical diagnosis in minutes.

3 – Nanoparticles help to better digest drugs in the humman body, it also has in facllitanig the production of these drugs, and also depends on it in the production of chemotherapy drugs for specific cells such as cells cancer.

4 - Fuel efficincy in the improving cars, in addition to helping to resist corrosion , by building car parts from nanomaterials that are characterized by the fact that lighter weight , stronger strength and more resistance for chemical reactions of the metal

5 –Nanofibers can improve resistance to fabric for stains, pollution , water and fire, without increasing the weight , thickness, or thickness of the fabric its hardness .

6 – water filter devices that nano more than 15 to 20 nanomaterials wide can remove small particales as small as nanomateriales , and thus get rid of all bacteria and viruses that may stick to them, at low costs .

7 – Carbon nanotubes are useful in many aspects such as producing more durable and lighter activity – related equipment as tennis rackets.

8 – Mpst sunscreens today are made of nanoparticales , they are very effective at absorbing light even at dangerous levels of ultraviolet rays . They also sparead more quickly into the skin. Factories are taking advantage of their advantage in absorbing UV rays by inserting them in composition of food packaging materials.

9 – The plastic in drinking bottles contains nano-plastics to prevent oxygen from infiltrating them and give them better carbon dioxide and moisture.

10 – Resistance programminga a variety of chemical sensors that are able to identity a specific chemical with great accuracy , such as one atom out of billions. Nanosensors are useful for accurately identifying cell of the body.