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A Review Article: Nanotechnology

Prathmesh Belkhode[1], Karteek Kotekar[2], Zaid Ameen[3], Linata Madame[4], Dr. Ravi Kalsait[5], Sheetal Dabre[6]
Central India College Of Pharmacy, Lonara , Nagpur, Maharashtra, India

Abstract: ***Nanotechnology is the exploitation of the unique properties of material at the nano scale. It is the engineering of functional system at the sub atomic level covers a broad range of topic and is focused on controlling and utilizing Nanotechnology is applicable to a large variety of sector like energy, environmental science, homeland security, medicines. Cardiovascular and cancer has been combat through nano medicines. (Application of nanotechnology in medicine) .***

I. INTRODUCTION

Over the past decade, there has been considerable research interest in the field of developing nano technology by using nanoparticles. Norio Taniguchi was the man who first initially utilized the term 'nanotechnology' (Professor of Tokyo Science University) in 1974. He started his research on the free abrasive mechanisms of high exactness machining of hard and brittle materials. Kim Eric Drexler is the founder and father of nanotechnology. He is the man behind theorizing nanotechnology top to bottom and promoting the subject. He is an American engineer best known for promoting the capability of sub-atomic nanotechnology, from the 1970s and 1980s.Nanotechnology deals with dimension and tolerance of less than 100 nanometer, especially the manipulation of individual atom and molecules . [2] A brief and general definition of nanotechnology is the statement by the us nation science and technology is the ability to work at the molecular level, atom to create large structure with fundamentally new molecular organization. The aim is to exploit these properties by gaining control of structures and devices at atomic, molecular, and supramolecular level and to learn to efficiently manufacture and use the devices. Nanotechnology is very diverse ranging from extensions of conventional devices physics to completely new approaches based upon molecular self-assembly, from developing new material with dimension on the nanoscale to direct control of matter on the atomic scale. At this scale the properties approach involving field such as applied physics, material science, chemistry, biology, surface science, robotics engineering, electrical engineering and biomedical engineering. At this scale the properties of matter is dictated and there are few boundaries between scientific disciplines [1]. The use of nanomaterial in everyday products can be generally divided into two types. First, nanomaterial can be merged or added to a pre-existing product and improve the composite objects' overall performance by lending some of its unique properties. Otherwise, nanomaterials such as nanocrystals and nanoparticles can be used directly to create advanced and powerful devices attributed to their distinctive properties. The benefits of nanomaterials could potentially affect the future of nearly all industrial sectors. The beneficial use of nanomaterial can be found in sunscreens, cosmetics, sporting goods, tyres, electronics and several other everyday .[11]

II. CLASSIFICATION OF NANOTECHNOLOGY

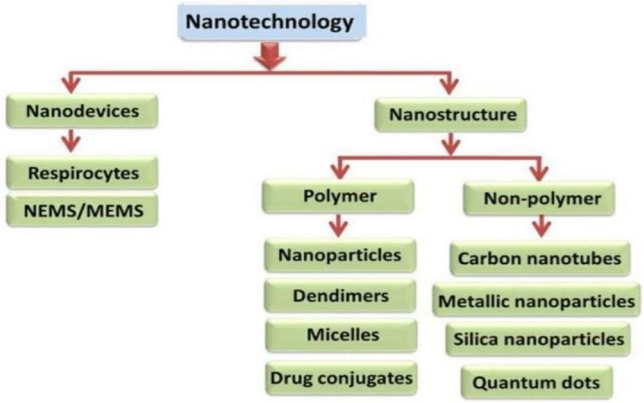


Fig :- 6.1 Classification Of Nanotechnology

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A. Carbon Nanotubes

Carbon nanotubes are cylindrical molecules. They have hexagonal network of carbon atoms . They consist of rolled up sheets of single layer of carbon atoms. Length of nanotubes is 1nm. Diameter of nanotubes is 1-100nm. They have two types: single walled nanotubes (SWNTS) and multi walled nanotubes (MWNTS). Due to more external surface area of carbon nanotubes, they can obtain high loading capacity as drug carrier. Carbon nanotubes are small macromolecule that are unique in size, shape and have special physical properties [4] .Their unique optical, mechanical & electronic properties give carbon tubes an imaging contrast agents and biological sensor.[3]

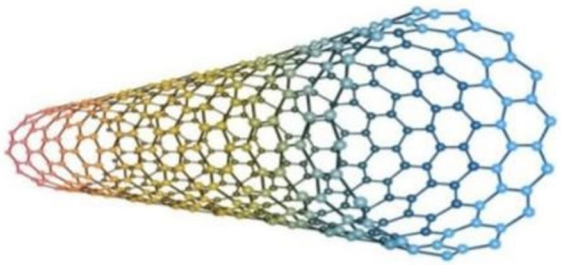


Fig :- 6.2- Carbon Nanotubes

B. Quantum Dots

Quantum dots are fluorescent semiconductor nano crystals.They consist of semiconductor core coated by a shell to improve optical properties size of quantum dots is 10-100 A in radius. This give vivo analysis, imaging, immunoassay, analysis of biomolecules, DNA hybridization and in non-viral vectors for therapy. them a unique physical characteristics. Quantum dots are primarily used to label the cells and in cancer treatment as therapeutic tool. Quantum dots are used in various techniques like in-vitro [5].

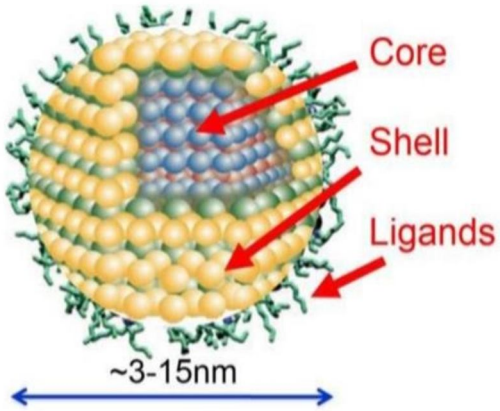


Fig :- 6.3- Quantum Dots

C. Dendrimer

It is Nano sized macromolecule having spherical structure. They are extensively used for drug delivery systems . This are hyper branched, tree like structure. They have compartmentalized chemical polymer. It contains 3 different regions core, branches and surface. The core forms central part and the branches radiate from it forming an internal cavity and a sphere of groups. The branches can be altered or Modified according to need. Dendrimer consist of huge void space in which drug molecule can be entrapped. This increase the solubility of drug molecule. Dendrimer are prepared by two methods. In first method dendrimer are constructed from core to border. This is known as divergent method. In second method, dendrimer are constructed from border to core [6].

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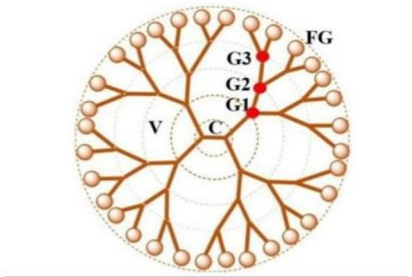


Fig 6.4 -Dedrimer

D. Polymeric Nanoparticles

These are colloidal carrier. They have size range of 10 nm-1000 nm. These nanoparticles have advantage like biocompatibility, non-immunogenicity, non-toxicity and biodegradability. Nanocapsules and nanosheres are 2 types of polymeric Nanoparticles. In nanocapsules, drug is present in central core surrounded by polymeric capsule. In nanospheres drug is dispersed throughout in polymeric matrix. Natural polymer like albumin, gelatin and alginate and synthetic polymers like polyesters are used in preparation of nanoparticles. Advantage of polymeric Nanoparticles are active and passive targetting, control and sustain release of drug, high drug loading [7].

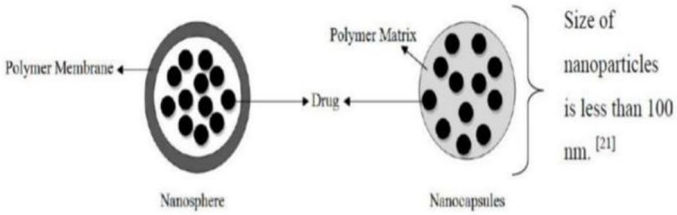


Fig:- 6.4 – polymeric nanotechnology

E. Liposomes

Liposomes are simple microscopic vesicles in which an aqueous volume is entirely enclosed by a membrane composed of lipid molecule. Liposomes are , made up of phospholipid and cholesterol having bilayer or multilayer surrounding an aqueous compartment. Liposomes are colloidal transporters. They have a diameter of 0.01-5.0µm. Liposomes have discovered in 1960 and since then they gained a lot of attention in drug delivery. They have been used to deliver various biological, anticancer drugs and cosmetics. Advantage of liposomes are increasing bioavailability of drugs, helps in drug targeting, biocompatibility, helps to reduce toxicity of certain drugs, can be administered through various routes and can be encapsulated to use biodegradable drug. Liposomes have 3 types on the basis of size and number of bilayer:[12]

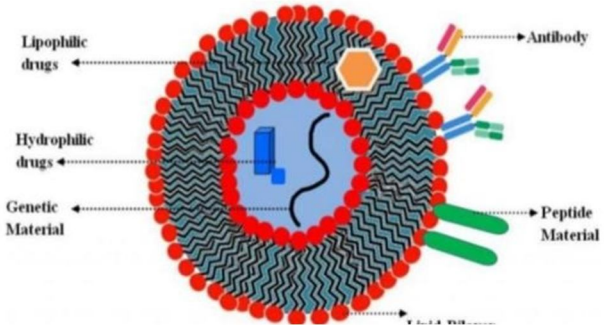


Fig:- 6.5 – Liposomes

1) Multi Lamellar Vesicals (MLV'S)

This type have several lipid bilayer separated from one another by aqueous space. They have difference in size ranging from few hundreds to thousands of nm in diameter [3] .

2) Small Uni Lamellar Vesicles (Suv's) And Large Uni Lamellar Vesicles (LUV'S)

These consist of single bilayer surrounding the aqueous space. LUV's have diameter of more than 100 nm SUV's have diameter of less than 100 nm. Drug is entrapped in the aqueous space as well as intercalated intolipid bilayer of liposomes, depending upon the physiochemical characteristics of drugs.On the basis of material from which liposomes are prepared, they are classified as pH - sensitve liposomes, conventional liposomes, immune liposomes, long circulating liposomes(LCL).

Different methods are used for preparation of liposomes like freeze drying, sonication , micro Empulsification , french pressure cell, lipid film hydration, ethanol injection membranes extrusion, double emulsification method ,ether lyophilization [8]

F. Polymeric Micelles

Micelles are amphiphilic surfactant molecule that consist of lipid and amphiphilic molecules.In polymeric miceles,amphiphilic and copolymer orient into nano scopic supra molecular core shell structure known as polymeric micelles. Size of polymeric micelles is less than 100 nm. Their are hydrophilic surface protects there non specific uptake by reticulo endothelial system. In micelles, lipid molecules or polymers orient itself in such a way that hydrophilic and orient towards aqueous phase and lipophilic in towards oily phase.

These micelles are used for systemic delivery of aqueous insoluble drugs. Drug molecule entrapped in hydrophobic core [9] .

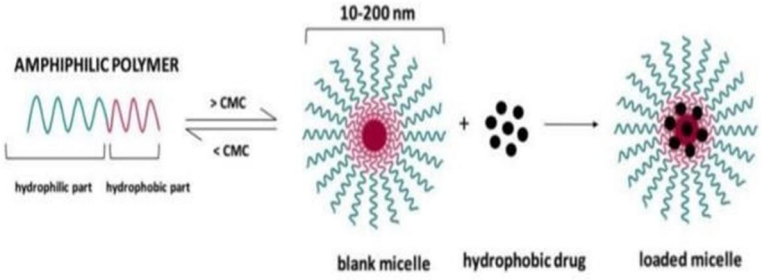


Fig :- 6.6 – Polymeric micelles

III. EXPERIMENTAL

*In order to illustrate the various characteristics of common analytical techniques, two sets of analyses were carried out.

- A series of commercially available nanomaterials were acquired. These were then subjected to a range of tests to investigate their composition.
- A MEMS sample with a monolayer-range thickness antistiction fluorocarbon coating that showed excessive stiction was also analyzed.

The following measurements will be discussed and illustrative examples shown:

1) TEM (Transmission Electron Microscopy)
2) XPS (X-ray Photoelectron Spectroscopy)
3) XRD (X-ray Diffraction)
4) AES (Auger Electron Spectroscopy)
5) TOF-SIMS (Time of Flight Secondary Ion Mass Spectrometry)

A. Transmission Electron Microscopy

The particles were actually not all spherical and, in fact, a range of shapes were observed. These positively charged species then attached on the negatively charged PSNPs through the electrostatic interaction to produce a PR-Au NP-capped PSNP system, the structure of which was later confirmed by Transmission Elecrton ha Microscopy(TEM) [JEOL 2010 , 200 kV]

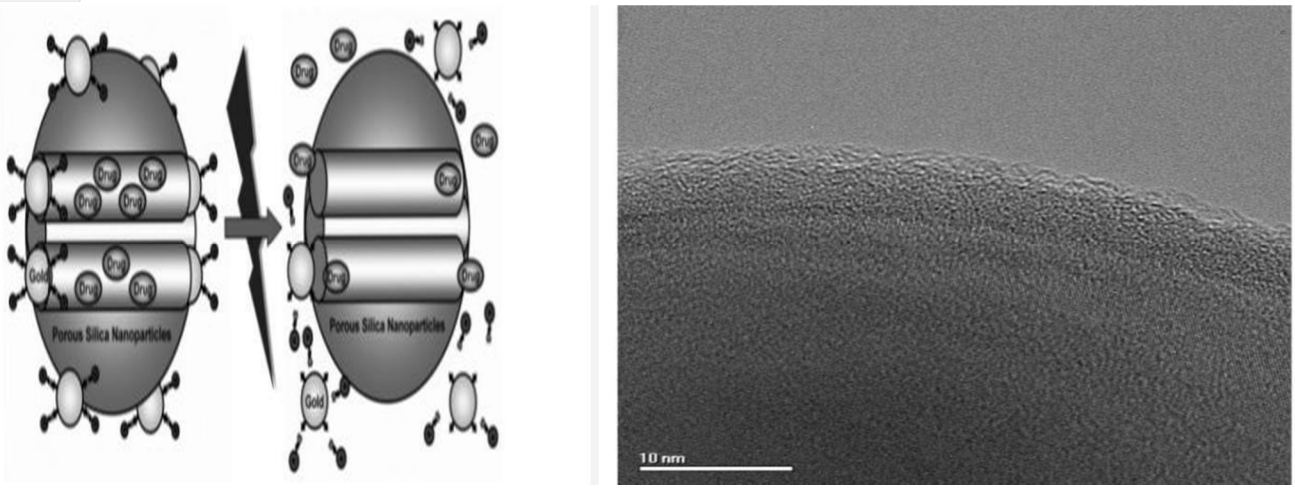


Fig :-6.7 :-Transmission Electron Microscopy

B. X-Ray Diffraction

The material detailed in this case was SiC (cubic) with an average particle size of 55nm. Figure 5 shows a 2q scan obtained using a Pan alytical X'pert Diffractometer. The predominant phase was found to be cubic, as expected, with minor contributions from hexagonal and or rhombohedral phases. The crystallite size of the primary phase was determined to be in the range of 22nm, i.e. substantially smaller than the average particle size of 55nm. This distinction showed that many of the particles consisted of multiple crystallites [11] .

XRD can provide useful information on the extent to which surface treatment of a carbon system has affected the bulk of the material. It is possible to use XRD in a thin film mode, employing very small take-off angles, to derive some surface information, but generally speaking it must be regarded as a bulk structural technique.

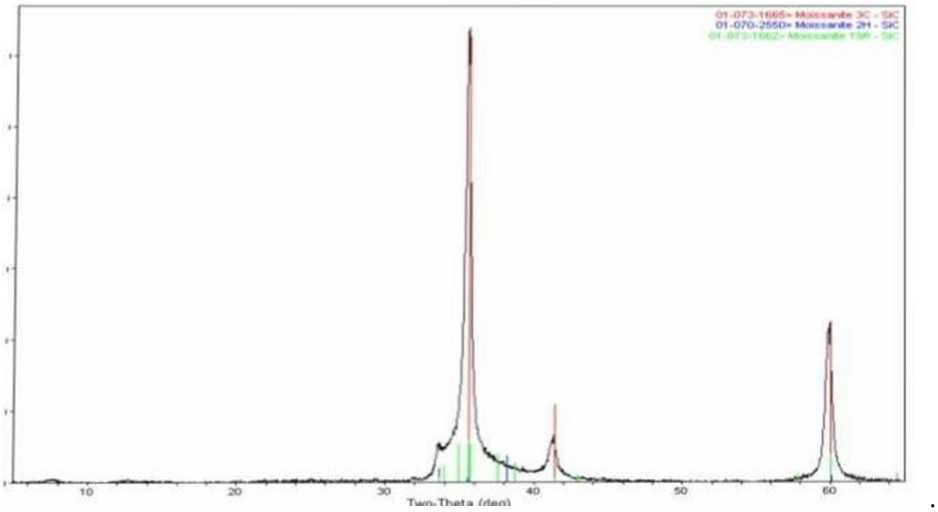


Fig 6.8 :- X-Ray Diffraction

C. Auger Electron Spectroscopy

AES is an excellent complementary technique to SEM (Scanning Electron Microscopy) in that AES can provide elemental maps with significantly better spatial resolution and surface sensitivity than SEM/EDS. The typical information depth for Auger is in the range of 30-60Å, with a spatial resolution in the 10nm range. Figure 6a shows an Auger SEM image obtained from a two-component nanoparticle (Al and Cu) mixture deposited on silicon. a copper elemental map and an aluminum elemental map, both obtained from the same area as the SEM image. The SEM image and maps were acquired using Physical Electronics 680 Scanning Auger Microscope and clearly show the distribution of the separate Al , Cu particle particles[11].

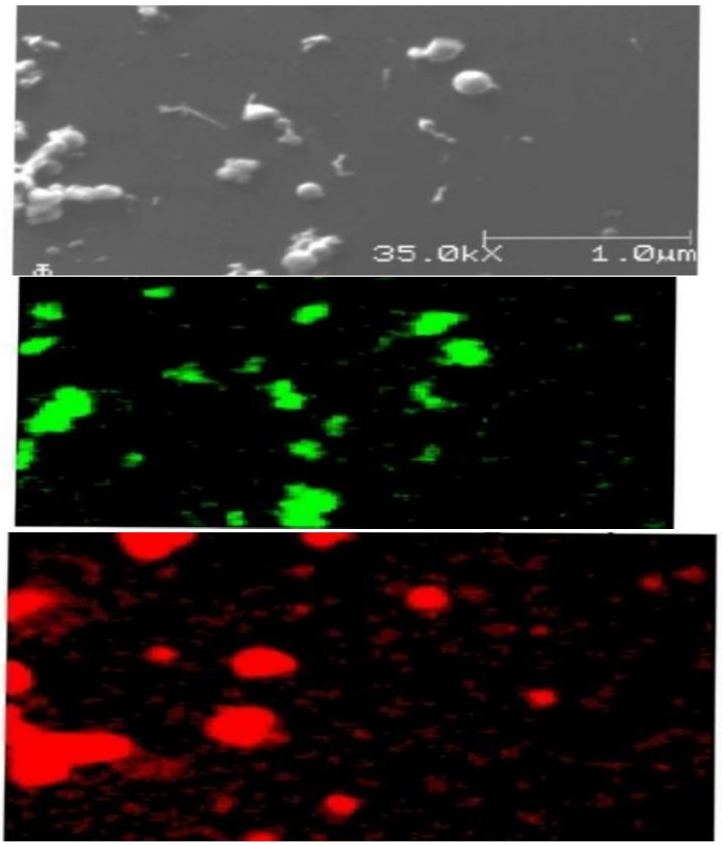


Fig :- 6.9- Auger Electron Spectroscopy

- *Time of Flight Secondary Ion Mass Spectrometry*

TOF-SIMS does not have the spatial resolution of electron beam techniques such as SEM, TEM or AES, however it has an extremely low information depth, in the range of 10-20Å, meaning that it can successfully provide information from surfaces covered by a monolayers or less of material. This extreme surface sensitivity makes it an ideal technique to examine low levels of molecular contamination on surfaces [12].

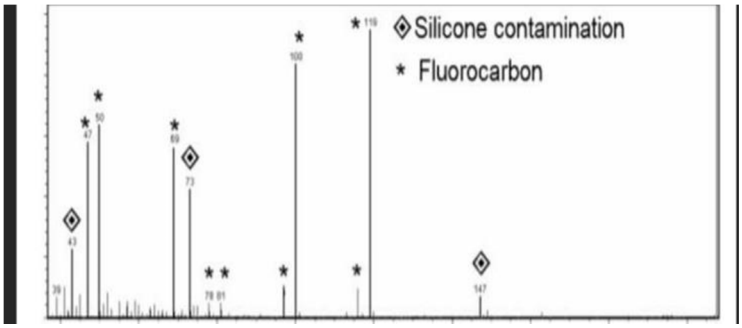


Fig:- 6.10 Contaminated surface

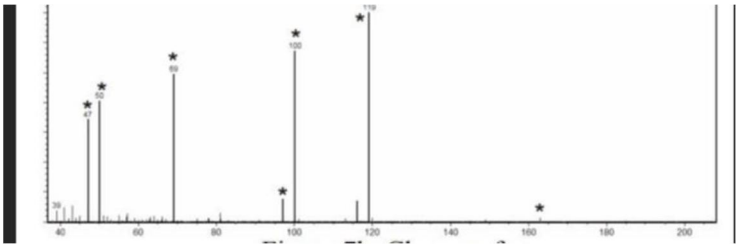


Fig :- 6.11 – Clean surface

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In the spectroscopy and imaging modes, only the outermost 1-2 monolayers of the sample surface are analyzed. To ensure the maintenance of these "static" conditions, a primary ion dose of less than 1012 ions/cm2 is employed. Below this "static limit," roughly less than one in one-thousand surface atoms or molecules are struck by a primary ion. The actual desorption of material from the surface is caused by a "collision cascade," which is initiated by the primary ion inside the sample surface. The emitted secondary ions are extracted into the TOF analyzer by applying a potential between the sample surface and the mass analyzer. Secondary ions are generated by a pulsed primary ion source (very short pulses of <1 ns).

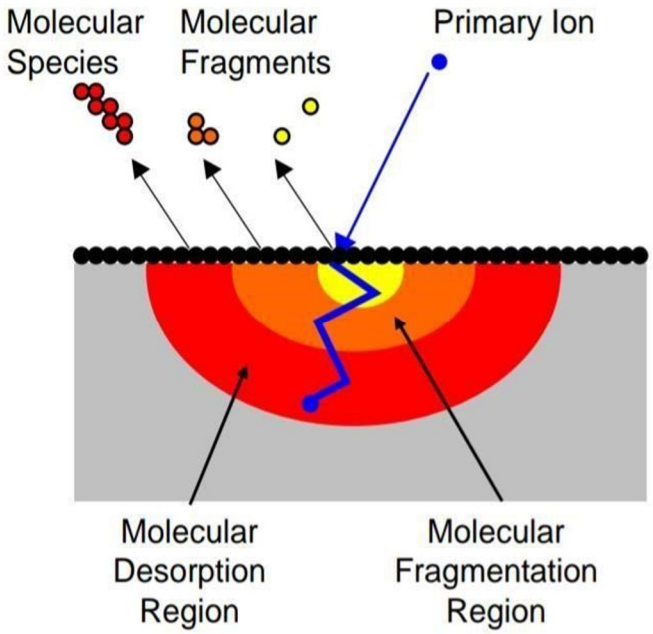


Fig :- 6.12 Static SIMS

The different methods are :-

1) Ampiphillic macromolecule cross linking.
a) Heat cross linking.
b) Chemical cross linking.

2) Polymerization Based Methods.
a) Polymerization of monomers in-situ.
b) Emulsion (micellar) polymerization.
c) Dispersion polymerization.
d) Interfacial condensation polymerization.
e) Interfacial complexation.

3) Polymer Precipitation Methods
a) Solvent extraction or evaporation**.**
b) Solvent displacement (nanoprecipitation). **C)** Salting out.

1) Amphiphillic Macromolecule Cross Linking

The materials used are Amphiphillic macro molecules, proteins and polysaccharides. These should have affinity to both aqueous and lipid solubility.

It occurs in 2 steps:-

a) Aggregation of amphiphillic.
b) Stabilization by heat denaturation or chemical crosslinking.

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The aggregation takes place in o/w or w/o emulsion type. These sub-divide the amphiphiles prior to aggregative stabilization. The aggregation may also takes place in-aqueous amphiphillic solution through removal, extraction, diffusion of solvent. The amphiphiles are aggregated as tiny particles and subsequently rigidised via chemical cross linking[13].

2) Polymerization Based Methods

a) Polymerization of Monomers in-situ

The polymers used are polymethacrylate, polyacrylamide, polybutyl cyanoacrylate, N-N' methylene- bis-acrylamide etc.

The two different approaches generally adopted for the precipitation of nano spheres using in-situ technique are:-

- The monomer to be polymerized is emulsified in a non- solvent phase (emulsion polymerization).
- The monomer is dissolved in a solvent that is non-solvent.

In emulsion polymerization, the monomer is dissolved in internal phase. In dispersion polymerization, it is taken in the dispersed phase. In both the cases the polymer is insoluble, thus results in a ordered suspension of nanospheres .

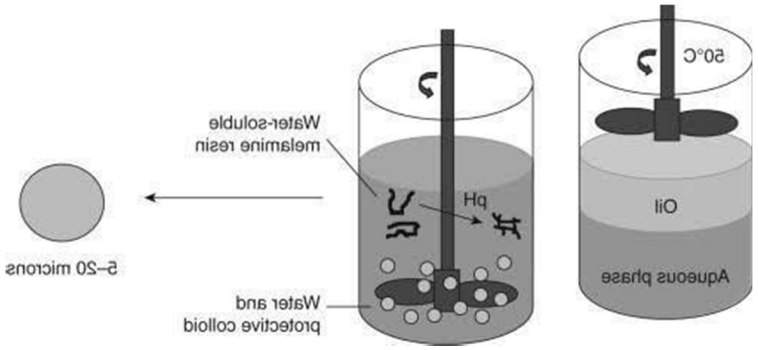


Fig 6.13 -Polymerization of monomers in-situ

b) Emulsion Polymerization

In the conventional case, the continuous phase is aqueous (o/w emulsion), in the inverse case it is organic (w/o emulsion). The two different methods proposed for the emulsion polymerization process are(Jain NK., 2001, De Jaeghere F et al., 1999, Ibrahim H et al., 1992 and Kreuter J., 1994).

- Micellar nucleation and polymerization.
- Homogeneous nucleation and polymerization.

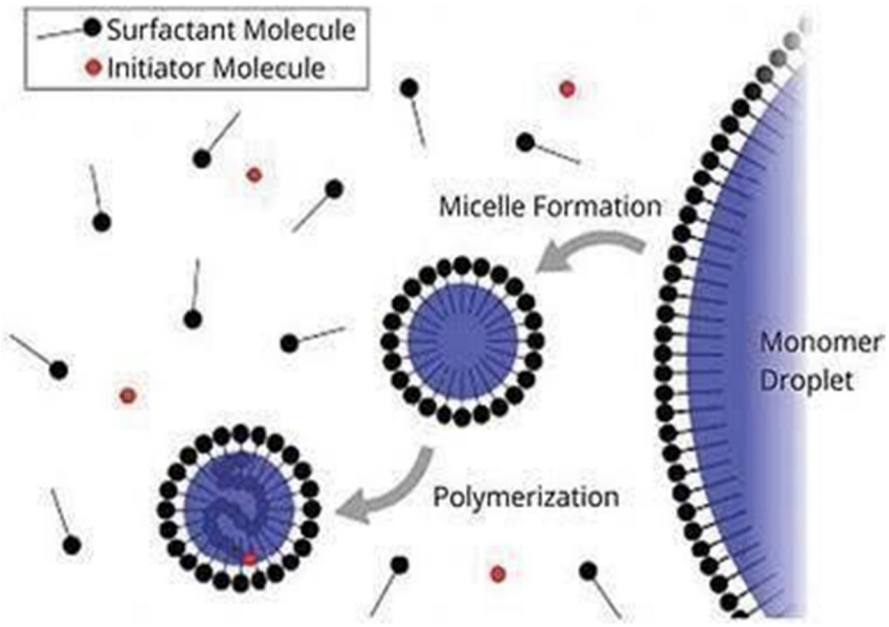


Fig :- 6.14-Micellar nucleation and polymerization

- *Micellar Nucleation and Polymerization*

The monomer is emulsified in the non-solvent phase with the help of surfactant molecules. This leads to the formation of monomers – swollen micelles and stabilized monomer droplets. Swollen micelles exhibit size in Nano metric range and this have more surface area than monomer droplets. The polymerization occurs in the presence of a chemical or physical initiator. The energy provided by the initiator creates free reactive monomers in the continuous phase, which collide with surrounding un-reactive monomers and initiative polymerization chain reaction [15].

- *Homogeneous Nucleation and Polymerization*

This process applies largely in case of where monomer is sufficiently soluble in the continuous outer phase. The nucleation and polymerization occurs directly in this phase, leading to the formation of primary chains called oligomers. Both micelles and droplets act as monomer reservoirs throughout thepolymer chain length. When the oligomers have reached a certain length, they precipitate and form primary particles, which are stabilized by the surfactant molecules provided by the micelles and the droplets. Depending on bulk conditions and system stability, the end product nanoshperes are formed either by additional monomer input into the primary particles or by fusion of the primary particle [14] .

- *Dispersion Polymerization*

The term emulsion polymerization is used when the monomer is emulsified in an immiscible (non-solvent) phase by means of surfactants. But in this monomer is dissolved in an aqueous medium, which acts as a precipitant for subsequently formed polymer. In insitu controlled polymerization the drug may be added to monomeric phase or may be added to the formed polymeric nanoparticles dispersion for adsorptive loading.

The polymerization is initiated by adding a catalyst and proceeds with nucleation phase followed by a growth phase (propagation). But in dispersion polymerization, the nucleation is directly induced in the aqueous monomer solution and the presence of stabilizer or surfactants is not absolutely necessary for the formation of stable nano spheres. This is used to prepare biodegradable polyacrylamide and poly methyl- methacrylate (PMMA) nano particles [3] .

- *Interfacial Polymerization*

In this the pre formed polymer phase is transformed to an embryonic sheath. The polymer that becomes core and drug.molecule to be loaded are dissolved in a volatile solvent. The solution is then poured in to a non solvent for both polymer and core phase. The polymer phase is separated as a co-acervate phase at o/w inter phase. The resultant mixture turns milky due to formation of nano capsules. This is used for encapsulation of proteins, enzymes, anti bodies and cells were employed [14].

- *Interfacial Complexation*

In this the pre formed polymer phase is transformed to an embryonic sheath. The polymer that becomes core and drug molecule to be loaded are dissolved in a volatile solvent. The solution is then poured in to a non solvent for both polymer and core phase. The polymer phase is separated as a co-acervate phase at o/w inter phase. The resultant mixture turns milky due to formation of nano capsules. This is used for encapsulation of proteins, enzymes, anti bodies and cells were employed [14].

D. Polymer Precipitation Method

In this, the hydrophobic polymer and or a hydrophobic drug is dissolved in a particular organic solvent followed by dispersion in a continuous aqueous phase, the polymer is insoluble. The external phase also contains the stabilizer. Due to the solvent miscibility techniques they are also known as solvent miscibility techniques they are also known as solvent extraction or evaporation method. The polymer precipitation occurs due to solvent extraction or evaporation. Firstly, polymer is dissolved in a suitable good solvent. After mixing in a poor solvent, which is miscible with the good solvent, the good solvent is gradually evaporated.

1) Increasing the solubility of organic solvent in the external medium by adding an alcohol.
2) By incorporating additional amount of water into the ultraemulsion (extract or diffuse solvent).
3) By evaporation of the organic solvent at room temperature or at accelerated temperature or by using vacuum.
4) Using an organic solvent that is completely soluble in the continuous aqueous phase (acetone) –nanoparticles [4].

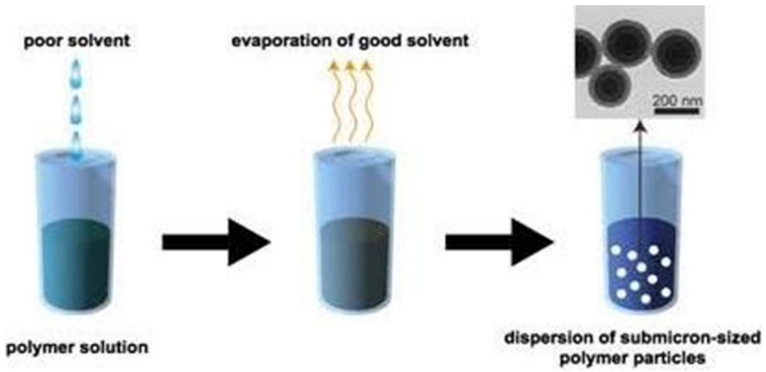


Fig 6.15 Self organize precipitation method

a) Solvent Extraction Method

This method involves the formation of a conventional o/w emulsion between a partially water miscible solvent containing the stabilizer. The subsequent removal of solvent (solvent evaporation method) or the addition of water to the system so as to affect diffusion of the solvent to the external phase (emulsification diffusion method) is two variance of the solvent extraction method. Recently emulsification diffusion method has been used on a regular basis for the solvent extraction purpose [16].

b) Solvent Displacement or Nanoprecipitation

This is based on the interfacial disposition of a polymer following displacement of a semi-polar solvent miscible with water from a lipophilic solution. This method involves the use of an organic phase, which is completely soluble in the external aqueous phase, inducing immediate polymer precipitation because of the complete miscibility of both the phases. Separation and extraction of the solvent is not required for polymer precipitation. After nanoparticles preparation, the solvent is eliminated and the free-flowing nanoparticles can be obtained under reduced pressure. and uniform in size. However, the loading efficiency of lipophilic drugs, such as indomethacin, metripranol, betaxolol in nanoparticles of PLA, PLGA and PECL has been increased using a modified solvent displacement method [17] .

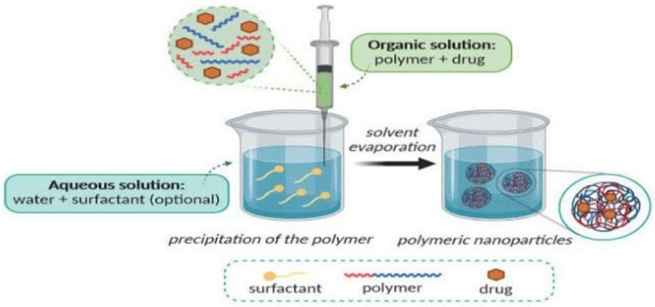


Fig 6.16 -Solvent displacement or nanoprecipitation

c) Salting Out

The presence of multiple polar functionalities (e.g., amides, alcohols, amines, etc.) generally increases the water solubility of organic compounds, often leading to difficulties in aqueous workups.

To address these situations, a number of techniques that fall under the umbrella of “enhanced extraction” have been developed

- Optimization of the extraction solvent and cosolvent (e.g., 1BuOH or other water-immiscible alcohols) can improve partitioning but usually only to a modest extent, if at all.
- Continuous liquid–liquid extraction overcomes poor partitioning by continual renewal of fresh solvent. Although continuous processing can offer many advantages, it requires significant capital investment and limits the portability of the process [18].

IV. APPLICATIONS OF PHARMACEUTICAL NANOTECHNOLOGY

A. Nano Materials for Tissue Engineering

The nanomaterials are used for tissue repair and replacement, Implant coatings, Tissue regeneration, Structural implant materials, Bone repair, Bio resoursable materials, Implantable devices (sensory aids, retina implants), Surgical aids, Operating tools and also in Smart instruments [3].



Fig 6.17-Nano materials for tissue engineering

B. Drug Carrier System

Nanotech enabled drug delivery system with optimized physical, chemical and biological properties, which can serve as effective delivery tools for currently available bioactives. Some nano-based carrier systems are polymeric nanoparticles, liposomes, dendrimer, polymeric micelles, polymer-drug conjugates, antibody-drug conjugates (Jain NK., 2001 and Song CX et al., 1995). These can be classified as

1) Sustained and controlled delivery system.
2) Stimuli sensitive delivery system.
3) Functional system for delivery of bioactives.
4) Multi-functional system for combined delivery of therapeutics, biosensing and diagnostic.
5) Site-specific targeting (intracellular, cellular, tissue).



Fig :- 6.18 -Drug carrier system

The main advantage deriving from the use of drug carriers is their ability to protect drugs during the overall administration time, enclosing them in external protective barriers of different types and nature; thus, reducing losses of active substances and limiting any side effects in patients Drug delivery systems are generally designed at nanometric and micrometric levels, to combine different properties with specific aims, such as site specificity, longevity, or external stimuli sensitivity[19] .

C. Molecular Diagnostics:- (Molecular Imaging)

It is representing, characterizing and quantifying sub cellular biological processes include gene expression, protein-protein interaction, signal transduction, cellular metabolism. They are used in magnetic resonance imaging, optical imaging, ultrasonic imaging and nuclear imaging. Other applications are specific labeling of cells and tissues, useful for long-term imaging, multicolor multiplexing, dynamic imaging of sub cellular structures and fluorescence resonance energy transfer (FRET) and magnetic resonance imaging (MRI).

MRI agents are replaced by nanomaterials like dendrimer, quantum dots, carbon nanotubes and magnetic nanoparticles. They are very efficient, stable, intense, M clearer image due to high intensity, photostability, resolution, resistance (Gupta P.k et al., 1987).Quantum dots, iron oxide nanocrystal and metallic nanoparticles [20] .

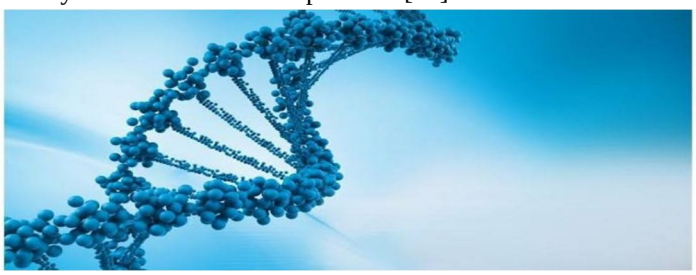


Fig 6.19-Molecular diagnostics:- (molecular imaging)

D. Biosensor and Bio-labels

These tools are employed for determination of various pathological proteins and physiological-biochemical indicator associated with disease or disrupted metabolic conditions of body. Biosensor is a measurement system that consists of a probe with a sensitive biological recognition element or bio-receptor, a physiochemical detector component and a transducer to amplify and transducer these signals into measurable form. A nano biosensor or nano sensor is a biosensor that has dimensions on the nanometer size scale. Biosensors are used in target identification, validation, assay development, ADME, toxicity determination [21] .

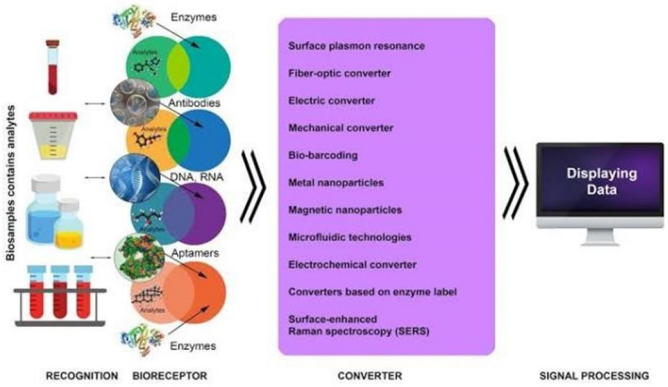


Fig :- 6.20 -Biosensor and bio-labels

E. Drug Delivery System

Nanotech helps in identification and validation of target by identifying the protein present on the surface or target surface. Nanotech will enhance drug delivery process, through miniaturization, automation, aped and reliability of assays. Single walled nanotubes are successfully usedto identify surface protein of pathogen. Quantum dots- track individual glycine receptors and to analyze their dynamics in the neuronal membrane of living cells, for periods ranging from milliseconds to minutes. Gold nano particles, nanobodies (smallest, available, intact antigen-antibody fragments) produced by ablynx are some commonly used nanomaterials in diagnosis. The pharmaceutical nanotechnology is used in the biodetection of pathogens in humans, separation and purification of molecules and cells and detoxifying agents. Future nan machine (respirocyte) is the nano-on-board mini computer,that can be used for detection of disease causing marker or antigen, to view the diseased site and to deliver the therapeutic agent at the site [19] .

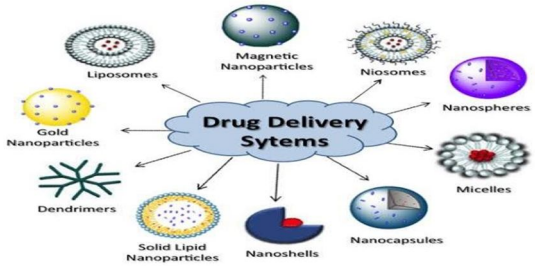


Fig 6.21- Drug delivery system

V. APPLICATIONS

A. Carbon-Based Sensors and Electronics

The semiconductor industry has been able to improve the performance of electronic systems for more than four decades by downscaling silicon-based devices but this approach will soon encounter its physical and technical limits.

B. Carbon-Based Nano-Sensors

In addition to the exceptional electrical properties of graphene and carbon nanotubes, their excellent thermal conductivity, high mechanical robustness, and very large surface to volume ratio make them superior materials for fabrication of electromechanical and electrochemical sensors with higher sensitivities, lower limits of detection, and faster response time [22] .



Fig :- 6.21-Carbon Based NanoSensors

C. Nanotechnology In Manufacturing

Nanomaterials can be designed to improve strength, flexibility, durability, lubricity and electrical conductivity compared to standard materials, as well as being resistant to numerous environmental conditions, such as glare, moisture, temperature, corrosion and even microbes. [23].

1) *Nanoengineered Polymers:* Thousands of nanoengineered polymers and hybrid polymer blends are available to manufacturers. Nanoparticles are embedded in the polymers at very specific concentrations and orientations, typically to increase strength, temperature and corrosion resistance.
2) *Nanomachine:* Researchers have successfully developed working nanomotors, nanorobots and nanomachines from chemical and biological molecules. These molecules selfassemble into functional, programmable nanoscale functional machines.



Fig 6.21 :- Nanomachine

D. Nanotechnology In Environment

Nanotechnology is impacting the field of consumer goods, several products that incorporate nanomaterials are already in a variety of items; many of which people do not even realize contain nanoparticles, products with novel functions ranging from easy-toclean to scratch-resistant. [24].

1) Foods

A complex set of engineering and scientific challenges in the food and bioprocessing industry for manufacturing high quality and safe food through efficient and sustainable means can be solved through nanotechnology [25] .

2) Nano-Foods

New foods are among the nanotechnology-created consumer products coming onto the market at the rate of 3 to 4 per week, according to the Project on Emerging Nanotechnologies (PEN), based on an inventory it has drawn up of 609 known or claimed nano-products.



Fig :- 6.22 - NANO-FOODS

3) Cosmetic

The nanomaterials-based cosmetic products mostly consist of nanosized ingredients and these provides unique and finer properties to a specific cosmetic products. These include; increased colour, improved qualities, deeper skin penetration, enhanced shelf-life, better ultraviolet (UV) rays protection, and many more. Among the various nanoparticles the micellar nanoparticles are the most popular in the cosmetic industry and are widely commercialized in both local and international markets [26] .

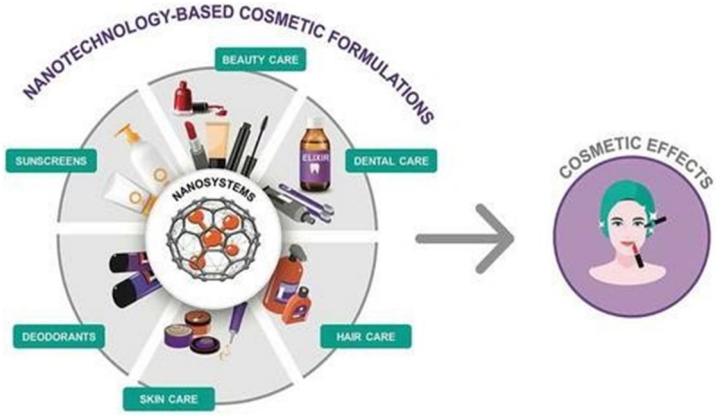


Fig :-6.23 – Cosmetics

4) Steel

Steel is a widely available material that has a major role in the construction industry. The use of nanotechnology in steel helps to improve the physical properties of steel. Fatigue, or the structural failure of steel, is due to cyclic loading. Current steel designs ar based on the reduction in the allowable stress, service life or regular inspection regime [27] .

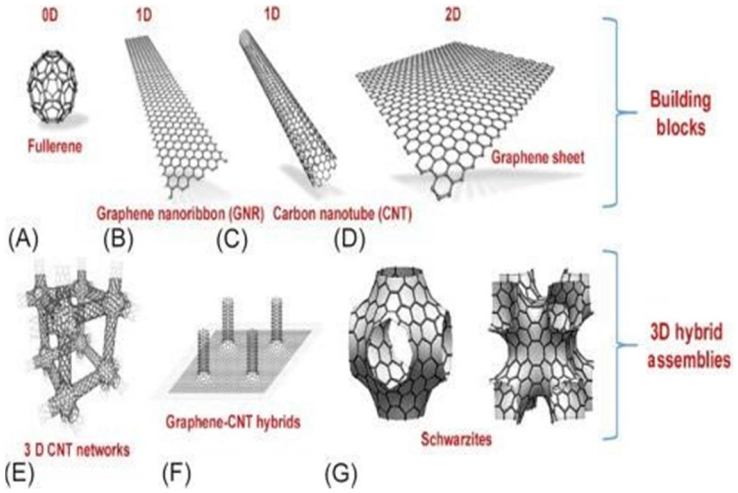


Fig:- 6.24 -Nanotechnology in industry

E. Nanotechnology In Industry

Nanotechnology has enormous potential for providing innovative solutions to a wide range of environmental issues. These include improved methods for reducing pollution, water treatment, environmental sensing, remediation, and making alternative energy sources more cost- The unique properties of engineered nanomaterials enable these novel technologies for meeting the environmental challenges in a sustainable way [28].

F. Nanobiotechnology

Nanobiotechnology, bionanotechnology, and nanobiology are terms that refer to the intersection of nanotechnology and biology. Concepts that are enhanced through nanobiology include: nanodevices (such as biological machines), nanoparticles, and nanoscale phenomena that occurs within the discipline of nanotechnology. This technical approach to biology allows scientists to imagine and create systems that can be used for biological research. Biologically inspired nanotechnology uses biological systems as the inspirations for technologies not yet created [29] .

G. Detection, Diagnosis And Mapping

Early-stage diagnosis of diseases has proven to be a long-standing challenge for researchers. Modern diagnostic techniques are mainly focused on detecting biomarkers in a body and determining relationships between them and disease progression.The sensitivity of nanodevices can be used to provide highly precise and accurate diagnoses through non-invasive methods.

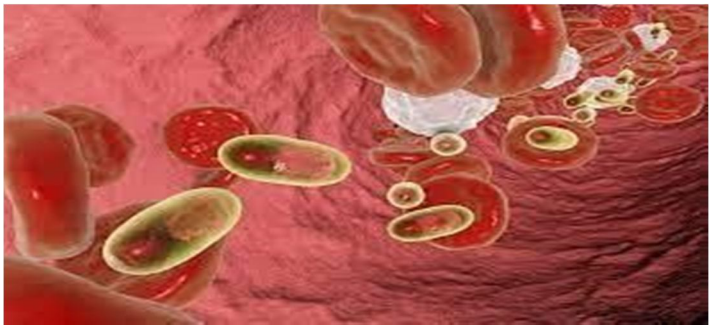


Fig :- 6.25- Detection, Diagnosis, and Mapping

- Nanotechnology also has applications in neuroscience, and it may be possible to noninvasively map the detailed workings of the brain to an extent that hasn't yet been achieved.
- Technologies like nanoparticle-based bio-bar codes can be used for ultrasensitive detection, enabling detection of very small concentrations of components like proteins, thereby increasing the chances of early-stage detection and diagnosis of diseases [30].

H. Cancer Treatment

A lot of the cancer treatment options facilitated by nanoparticles are an extension of the capabilities mentioned above- targeted drug delivery, early diagnosis, mapping and labeling tumors, and so on.

Chemotherapy can be targeted and delivered only to cancerous cells, thereby drastically increasing the efficiency of treatment and reducing the side effects associated with it. Recently scientists performed successful experiments to show that bowel cancer survival rates could be improved through such targeted delivery of chemotherapy Using nanotechnology to deliver immunotherapy has also been proven successful in patients [30] .

I. Nanomedicine Against COVID - 19



Fig 6.26 :-Nanomedicine Against covid – 19

Researchers around the world are working around the clock towards preventing and controlling the coronavirus pandemic, and nano technology has had a significant role to play.

- *Vaccine Development:* The Pfizer mRNA-based vaccines are made usable by the backing of nanoparticles. Nanoparticles can target cells part of the immune system for better delivery.
- *Treatment:* There is great potential for use of nanotechnology for improving the effectiveness of COVID19 treatment. Fabrication of nanoparticles with desirable characteristics could result in treatments with less toxicity, and therefore less adverse effects, and faster results.

Research is still being done on fully realizing the possible contributions of nanotechnology in the fight against COVID-19, but needless to say, the potential is noteworthy.

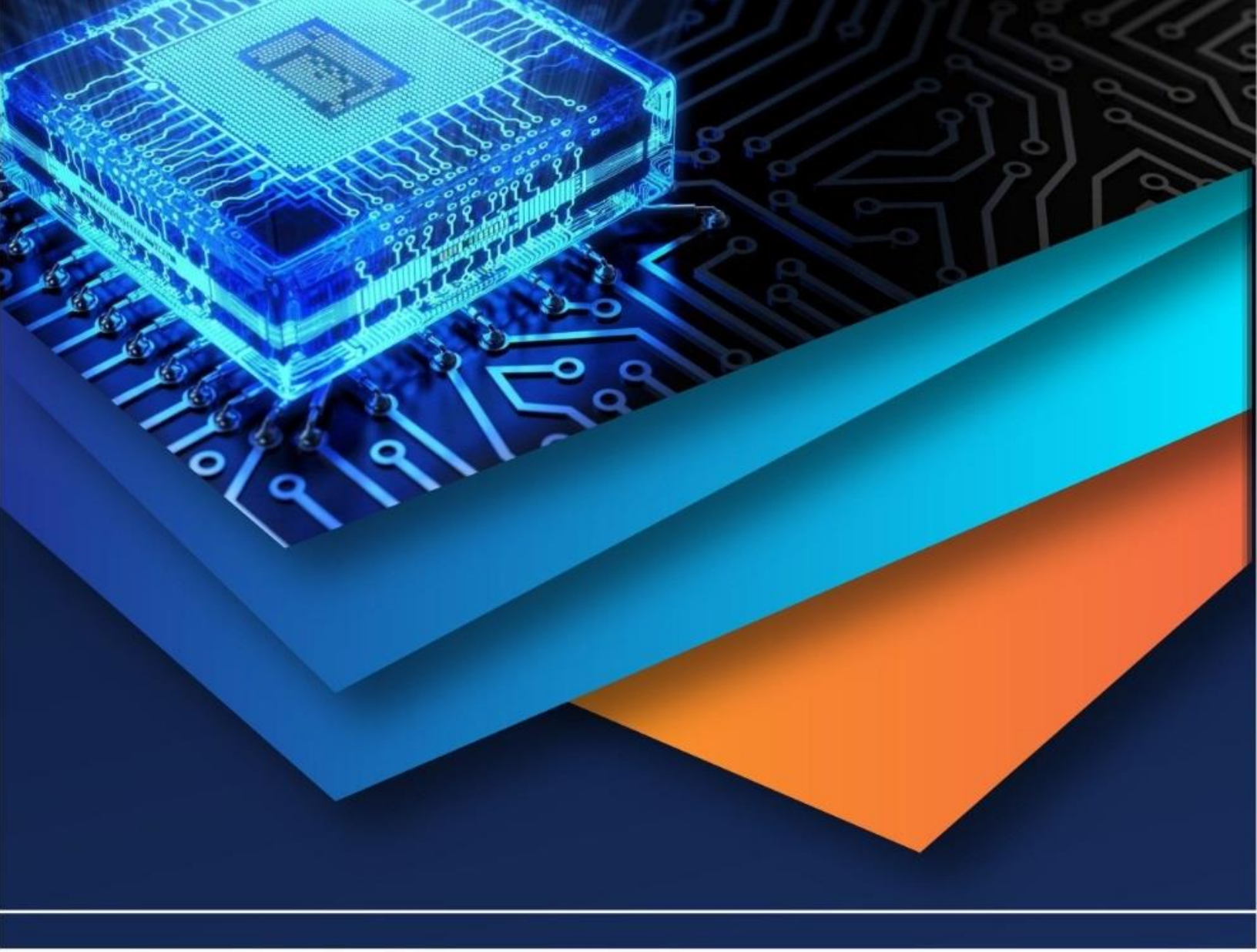
VI. CONCLUSION

As a conclusion to this topic I would like to say that Nanotechnology is a brand new technology that has just began, it is a revolutionary science that will change all what we knew before. The future that we were watching just in science fiction movies will in the near future be real. This new technology will first of all, keep us healthy because of Nano robots that will repair every damage that we have in our body. Nanotechnology will give us an abundant energy because it will transform energy more effectively. Nanotechnology covers a lot of domains today and will cover a lot more in the near future, it is infinitely big and will make a lot of inventions come true like teleportation for example which scientists are working on today.

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