

Dissertation submitted in partial fulfillment of the requirement for the degree of

**BACHELOR OF TECHNOLOGY
IN
BIOTECHNOLOGY**

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UNDER THE GUIDANCE OF

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MAY 2022

CERTIFICATE

This is to certify that the work reported in the Bachelor of Technology academic report submitted by **Samya Khanna**, in partial fulfillment for the award of degree of B.Tech. Biotechnology from **Jaypee University of Information & Technology, Waknaghat** has been carried out under my supervision. This report was not submitted to any other University or Institute in full or in part for the award of any other degree, certificate or other titles.



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DECLARATION

I hence state that the work reported in the B.Tech. academic report submitted at **Jaypee University of Information Technology, Wagnaghat** is an authentic record of my work carried out under the guidance and direction of **Mr Arun Gupta**. I have not presented this work somewhere else for any other degree or qualification. Samya Khanna (181804) Department of Biotechnology & Bioinformatics JUIT, Wagnaghat Certified that the student 's statement above is accurate to the best of our knowledge and belief. Roots Analysis holds the copyright of the results reported in this article. In no circumstances will the information be exchanged with third parties without the company's prior consent.

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ABSTRACT

(Basis of Nanotechnology)

“Ultra small has the potential to make enormous large in the world”

Nanotechnology can revolutionize many fields such as industrial, medical, technology, electronics, environmental science, homeland security, etc.

It is a multidisciplinary scientific field that consists of physics, chemistry, biology, biotechnology, mechanical, electrical engineering, material science, etc. We don't realize the massive impact nanotechnology has on our daily lives.

In a nutshell, nanotech is a study of structures at a minute scale (1-100nm) called the nanoscale, 1nm is a billionth of a meter, for a better understanding, supposedly the diameter of earth was 1m then the diameter of a marble would be 1nm.

Properties of particles (physical, chemical, electrical, optical, mechanical properties) change at the nanoscale.

Quantum mechanics comes into play at this scale as Newtonian theories along with classical mechanics fail at the nanoscale. According to National science Foundation, Nanotechnology is the capability to understand, manipulate and control matter at the level of individual atoms and molecules [1]. Science and engineering are the primary operators of global technological competition[1]. Modern science contributes a new foundation for innovation, knowledge, and integration of technology .This article gives a brief about the key principles of nanotechnology.

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1.1 Introduction and history

Nano science is the detailed study of the properties, structures and behaviours of nanoparticles. It is a cross-disciplinary field, i.e., it is studied by scientists of different fields such as physics, chemistry, biology, electronics, etc. Whereas Nanotechnology is the study of design, application, substance of devices and systems at the nano-scale. So *“Nano science is the study of nano materials and their properties and Nanotechnology is using this knowledge to create something new”*. For any particle to be called a nanoparticle at least 1D of that material should be less than 100 nm.

1D nanoparticles – at least one dimension should be less than 100 nm e.g. thin films

2D nanoparticles - at least two dimensions should be less than 100 nm e.g. nanotubes

3D nanoparticles - all three dimensions should be less than 100 nm e.g. quantum dots or nanoparticles.

History

The concept of observing particles at an ultra small scale was first proposed by Richard Zsigmondy at the start of the 20th century who coined the term Nanometre and he was the first to measure the size of particles such as gold colloids, whereas Nanotechnology was first discussed by **Dr. Richard Feynman** an American physicist in 1959 in his talk “There is plenty of room in the bottom” on which he discussed the idea of writing an entire encyclopedia on a head of a pin and observing it with an electronic microscope and manipulating matter at an atomic level.

The term nanotechnology was first used in 1974 by Norio Taniguchi, In 1986 the term nanotechnology was used by K. Eric Drexler in his book “ Engines of creation: The coming era of nanotechnology” which was inspired by Dr. Feynman’s concepts.

Nanotechnology was just a mere concept before the 1980s but it emerged as a massive field after the discovery of scanning tunneling microscope in 1981 as now we could not only visualize but manipulate nanoparticles. This was done around 1989, so in the early 2000s advances were made in Nanotechnology and it gained popularity as well as criticism around this period.

Funding for researches in this field started happening around 2006. The top five companies that filed the most intellectual patents on nanotech around 1970-2011 were Samsung Electronics, Nippon steel, IBM, Toshiba, and Canon.

1.2 Scale

A nanometer is 1×10^{-9} meter i.e. a billionth of a meter , in simpler terms we can see a least of 1cm to 1mm with our eyes , a magnifying glass helps us see less than a millimeter i.e. (1/1000 of meter) , with the help of a microscope is can see in micrometers (1\1000 of a millimeter) , using a nanometer helps us see in nanometer i.e. (1\1000 of micrometer) . It is difficult to understand how small a nanometer is so here are some examples

1. A sheet of paper is 100,000 nm thick.
2. A human hair is 80,000-100,000nm wide.
3. One nm is as long as your fingernail grows in one second.
4. Our RBC is 7000nm wide.

1.3 Instruments

To observe the ultra small we need the biggest of machines

Because nanoparticles are smaller than the wavelength of light (400nm-700nm) , they cannot be visualized by optical microscopes , traditional microscopes can magnify upto 1500 times . So we use electronic microscopes they can magnify upto 1 million times , we were able to observe the nanoparticles as early as 1930's using SEM (scanning electron microscope) , TEM (transmission electron microscope) , FIM (field ion microscope) .

SEM: Scanning electron microscope is a type of electron microscope that scans the surface of the nanoparticles and produces an image, the electrons interact with the atoms of the surface which produces signals about the composition of the samples , SEM is based on the principle that the source releases primary electrons which gives energy to atomic electrons of the specimen which then releases secondary electrons and an image is formed by collecting secondary electrons from each point of the specimen , SEM helps in high resolution imaging and produces accurate 3D images , one of the drawbacks of using SEM is that it is expensive and machines are very large.

TEM: Transmission electron microscopy is considered as the best technology for characterization of nanoparticles , TEM operates on the same principle as a basic microscope the only difference is that it uses electron beam instead of a light beam . The beam of electrons is transmitted through the specimen to form an image, it produces a 2D image , the only difference between SEM and TEM is that SEM creates an image by detecting reflected or knocked off electrons , while TEM uses transmitted electrons (electrons that are passing through the samples) to create an image.

FIM: Field ion microscope was invented by Muller in 1951 , this microscope is used to image the arrangement of atoms at a surface of a sharp metal tip , The principle of FIM is that field ion image is produced by projection of image gas atoms that are ionized by high positive voltage on the specimen onto the fluorescent screen

In recent years technologies like STM (scanning tunnelling microscope) , AFM (atomic force microscopy) , holography etc have allowed us to not only observe but also manipulate nanoparticles and look at them in 3D level.

STM: this instrument is for imaging of surfaces at an atomic level was developed in 1981 this microscope senses the surface by using extremely sharp conducting tip can that distinguish features smaller than 0.1 nm with 0.01nm, it is based on the concept of quantum tunnelling , it can be used in air , water , high vacuum and temperature between near zero to few 100⁰ c.

AFM: atomic force microscopy or scanning force microscopy is a very high resolution type of microscopy it has the ability of manipulation , topography imaging ,and force management , it allows 3D characterization of nanoparticles with sub nanometer resolution , using AFM has many advantages as compared to electron microscopy , and other characterization methods.

Holography: it is a method of 3D imaging can be used for the detection of nanoparticles , holography is basically a real world recording of an interference pattern in other words just like we can record our voices using a sound recorder similarly we can record and capture light waves and images and use it advances in holography were made afte the discovery of lazer , we can recover the size of nanoparticles using holography.

1.4 PROPERTIES

The properties of matter change when you go ultra small , so when the particle size reduces to nanoscale the properties such as melting point , electrical conductivity , magnetism etc change as the function of the size of the particle.

For example gold is yellowish golden in our macroworld but when we look at it at nanoscale it colour changes to reddish and it depends on the size of the particles , it is inert (chemically inactive) in general but at nanoscale it is chemically reactive . we are not making any changes in the particles just exploring more surface area . surface area which is also one of the most important properties of the nanoparticles , when the particle size is reduced the surface area to volume ratio increases , as a result many properties like catalysis etc are enhanced , catalysts work at a large surface area so they speed up the processes .

The properties we will be discussing here are ;

- Optical properties
- Physical properties
- Chemical properties
- Magnetic properties
- Electrical properties
- Mechanical properties

OPTICAL PROPERTIES: The properties of matter that define how it interacts with light

.
Materials they absorb light restriction in size results in restriction of electrons to move , but at nanoscale , Nanomaterials have small particle size and as a result they show enhanced optical emission as well as nonlinear optical properties due to QUANTUM CONFINEMENT EFFECT which means that as the size decreases the bandgap increases , bandgap is the energy difference between the top of valance band and bottom of induction band , so large bandgap means more energy is

required to excite the electron so it can be said that as the size decreases the energy to excite the electron increases.

In nanotechnology Quantization takes place i.e there is restriction in number of possible values (discrete) so when the size decreases the number of electrons also decreases . The optical energy bandgap also influences the surface plasmon resonance of nanomaterials SPR is a result of coherent excitation of free electron of nanoparticles and the intensity of SPR is directly proportional to the number of excited electrons ¹

PHYSICAL PROPERTIES : these are the properties of matter that are not associated with change in the chemistry example absorption , area , boiling point , adsorption etc when the size decreases the interatomic spaces decrease enhancing the physical properties

MECHANICAL PROPERTIES : these are the properties that are observed on the application of force some of these properties are strength , toughness etc Materials that are present in bulk have more room for deformation and as the size reduces the room for deformation reduces and as the size reduces there are lesser imperfections so more tough and strong materials .

ELECTRICAL PROPERTIES : Properties of a substance which determine its response to an electric field , as the size of particles decreases the bandgap increases so as a result some metals become semi conductors and semi conductors become semi conductors become insulators , also increase in bandgap increases the resistivity except in some cases ex plastic.

CHEMICAL PROPERTIES : these are the properties that become evident during or after a chemical reaction ex of chemical properties are reactivity , acidity ,flammability etc , nanoparticles are more reactive as compared to bulk materials because of their high surface area to volume ratio so the chemical properties are enhanced at nanoscale

MAGNETIC PROPERTIES : The properties exhibited by materials in the presence of a magnetic field , nanoparticles tend to show SUPERMAGNETISM in the presence of a magnetic field and no magnetization in the absence of magnetic field .

The reason for a massive change in the properties of nanomaterials cannot be explained by classical mechanics or Newtonian physics but by QUANTUM PHYSICS , classical physics fail to explain the change in the properties , Quantum physics is the study of matter and its interaction with energy at atomic and subatomic level quantum physics is a basic research area in nanotechnology , when a particle is 100nm or less it is supposed to be in a QUANTUM REALM , in classical physics an object can be at one place at a specified time but in quantum mechanics object is in a haze of probability that have a chance of being at a point A or point B , nanoparticles are sometimes also called Quantum dots (they are semiconductor particles few nanometers in size central topic in nanotechnology , quantum dots are tiny crystals when light is passed through a nanocrystal or a quantum dot it gives colour and the colour is based on the size of the particle . so nanoparticles have no definite properties but they rather change with different sizes so simply put the properties of nanoparticles change with the change in their sizes .

This can be understood with an example of a bell when a bell big in size it struck low energy sound waves are produced of high wavelength and low pitch , and when a bell of small size is struck it produces high energy sound waves resulting in high pitch and low wavelength ; similarly when light excites a quantum dot larger in size lower energy waves which means high wavelength light which is REDDER LIGHT is produced and when light excites a quantum dot smaller in size high energy waves as a result smaller the wavelength which is BLUER LIGHT is produced .

1.5 Methods of preparation of Nanoparticles

There are three methods of preparation of nanoparticles that follow up 2 approaches that is

Top down: starting from bulk and breaking down in smaller parts (physical methods)

Bottom up: building what is desired from the building blocks that is atoms , atom by atom or molecule by molecule or cluster by cluster (chemical methods) .

The methods of preparation are

1 Physical methods

2 Chemical methods

3 Biological methods

Physical methods can be of two types

Mechanical method (mechanical milling) and vapour method (physical vapour deposition)

Chemical methods can be sol gel , colloidal method , chemical vapour deposition .

Biological methods and be done using plant or microorganisms.

PHYSICAL MEHODS :

Mechanical milling : top down process

the nanoparticles are formed in a mechanical devise called a “mill” where a metallic ball breaks the material is nanosized particles the particles are trapped between two colliding balls the balls break the macroparticles into nanosized particles .

the balls rotate with high energy inside the container and the fall on the solid because of the force of gravity

Melt blending

For the preparation of polymer nanocomposites , the polymer is melted and then combined wit the required amount of intercalated clay using banbury or extruder , melt blending is done in the presence of an inert gas and has great advantages over

the normal polymerizing .it is no harmful to the environment and thus a very popular method .

Laser ablation

Laser is used to vaporise the material the nanoparticles are generated by laser ablating the solid target that is liquid or gaseous in environment , it is environment friendly and the generated nanoparticles are ultrapure the wavelength of laser that is used is approximately 200 nm .

Physical vapour deposition

Atoms are deposited on the substrate via *evaporation or sputtering* also called vacuum deposition as they are done in evacuated chamber .

So in thin film deposition through *evaporation* the atoms that are evaporated travel through the evacuated space that is between the source and the sample and they stick to the sample.

In thin film deposition through *sputtering* , in sputtering there is re emission of of the deposited material , a plasma is made ionizing a sputtering gas.

CHEMICAL METHODS :

Chemical vapour deposition : it is a method of deposition that produces solid material which is of good quality and good performance , usually used to produce thin films , most of the reactants are gasses and thus it is very economical , as compared to PVD , CVD is thicker and the coating protects against heat whereas PVD is a line of sight coating process.

Sol gel method : one of the great advantage of sol gel method is to obtain very stable and high surface area nanoparticles ,there are 2 main reactions in sol gel

- 1) hydrolysis of precursor in acidic or basic medium
- 2) polycondensation of hydrolysed product .

This method is mainly used for the production of ceramic and glass material in form of thin fibers or powder .

Electrochemical method : although there are several methods to form nanoparticles , electrochemical process is one of the most widely used it is an efficient method for the fabrication of nanoparticles , it is highly efficient as it is cost effective , environment friendly and very pure . mainly used for the synthesis of silver nanoparticles , the main principle of this technique is to convert one chemical parameter of a medium into an electrical parameter by an appropriate instrument .

Green synthesis

Nanoparticles are produced using plants and microorganisms this method has recently increases as the products are eco friendly and stable .

Through plants : the method is photosynthesis and plants have certain phytochemicals present in them that act as reducing and stabilising agents for nanoparticles , mainly metal nanoparticles are produces using this method . we can use plant extracts like shoots , roots , fungi , bacterial etc they have applications in many fields like medical , environmental , optical etc

The main steps involved are taking fresh leaves of a plant and cutting it finely , adding water and heating in a hot plate for some time then filtering it using filtration , the leaf extract is obtained which is mixed with a precursor solution (different for different nanoparticles) , the next step is bio-reduction using metallic ions , nanoparticles are formed which are further characterized .

Through microorganisms

The methods can be

- Intracellular (inside the cell)
- Extracellular (outside the cell or in between the cells)

Intracellular method : in this method bioaccumulation takes place which means that the particles inside the cell have to be accumulated so for this steps such as ultrasound or us of chemicals is done

Extracellular synthesis : this method involves biomineralization , biosorption , bio
precipitatio,This method is mainly used for silver nanoparticles.

1.6 Types of nanoparticles

Gold nanoparticles (Au NP's)

Gold nanoparticles are one of the most important nanoparticles and are used for diagnostics , therapeutics , biomedical applications and much more .

Synthesis : they are synthesized when hydrogentetrachloroaurate (HAuCl_4) is treated with citric acid in boiling water.

Properties :

- Large surface area to volume ratio
- High biocompatibility
- Low toxicity (inert gold is not toxic)
- Surface plasmon resonance
- Quench florescence

- Absorption from 500-nm this absorption band is surface plasmon band not seen in bulk and small materials

- Readily conjugate with moieties like antibodies etc for detection of biomolecules like cancer.

Trojan horse technology

It is a very important technology to treat different tumours and cancer therapy in human aggressive form of brain cancer GBM glioblastoma multiforme one of the most common brain tumors In adults .

Silver nanoparticles

These nanoparticles are commonly seen in photovoltaics , sensors , antimicrobial coatings have good optical properties good in absorbing and scattering light because of surface plasmon resonance

Synthesis : various methods of obtaining the silver nanoparticles include electron irradiation, laser ablation , chemical reduction etc .

Applications :

- Easily visualized under microscope
- Diagnostics : early detection and early treatment more chance of a cure eg. In cancer
- Therapeutics : quick healing of wounds
- Oncology : destruction of cells after AgNP treatment
- Silver bullet : understanding of medical illness , it is a little complex
- Orthopaedics : artificial joint replacement.

Iron oxide nanoparticles

These nanoparticles are highly reactive because they have large surface area , they for free ions in the presence of oxygen (O₂) and water (H₂O) have enormous applications in the medical field .

Synthesis : when isobutanol is precipitated with sodium hydroxide and ammonium hydroxide the nanoparticles are produced and are calcined for 100 min to 5 hrs in the range of 300 to 600° C . (2)

Properties :

- Non toxic in nature
- High surface area , high magnetic , thermal and electrical properties
- High melting 1500° c and boiling point 2759° c
- Highly reactive good catalytic properties
- High magnetic properties , superparamagnetism seen only in iron nanoparticles

Applications :

- tissue repair
- drug delivery (SCION)
- cell separation
- immunoassay
- detoxification of biological fluids

Top 3 nanoparticles

1. Zinc oxide nanoparticles
2. Silicon nanoparticles
3. Titanium nanoparticles

Zinc oxide nanoparticles

Zinc is considered to be the *legacy nanomaterial* .

Synthesis : via sol gel method zinc acetate dehydrate ($\text{Zn}(\text{CH}_3\text{COO})_2 \cdot \text{H}_2\text{O}$) is used as a precursor and ethanol (CH_2COOH) which is used as solvent and sodium hydroxide (NaOH) and distilled water is used as medium .

Applications

- Sunscreen's absorbs harmful UV rays
- Therapeutics
- Antibacterial , anticancer
- Light absorbers

- More effective against microbes
- Radioactive wastewater decontamination

Disadvantages

- It is a carcinogen
- It has bad environment effects and is toxic in nature
- Toxic to kidney , stomach , neurological system
- Not easily characterized by UV

Titanium dioxide

It has many applications and is manufactured worldwide , it is much safer than zinc and does not result in many diseases in human beings as such it is considered a safe nanoparticle by the scientific committee on consumer safety (SCCS) .

PREPRATION : it is prepared using many techniques using sol gel , metal organic chemical vapour deposition (MOCVD) , gas phase synthesis etc , one of the common methods of TiO_2 preparation is the sulphate process where titanium slag or ilmenite ($FeTiO_3$) is digested by sulphuric acid.

Properties :

- High melting $1803^{\circ}C$ and boiling points $2972^{\circ}C$
- Insoluble in water
- Insulator
- Inert earth mineral

Applications :

- Sunscreens protection from UV A and UV B
- Artificial joints
- In food industries
- Reducing toxicity of dyes
- Waste water treatment

Silicon

Excellent biocompatibility , low toxicity , thermal stability , site specific targeting

Properties :

- High melting boiling properties
- Surface tailorable photoluminescence
- DNA detection , separation , purification

Applications

- Antimicrobial drugs
- Cancer therapy
- Sensors
- Contrasting agents

1.7 APPLICATIONS OF NANOTECHNOLOGY

BIOMEDICAL SCIENCES: Nanotechnology has vast applications in the field of biomedical sciences like drug delivery , drug analysis , diagnostics , therapeutics .nanoparticles can be used for the early detection and treatment of diseases such as cancer , nanoparticles like gold are important for fields such as cell biology , research and tissue culture and diagnostics.

Therapy : nanoparticles can be used in therapy where tumour targeting and integral drug delivery using nanoparticles like iron and gold it has also opened the door to regenerative medicine such as regeneration of tissue , organs etc ,

Biosafety : the biosafety has to be examined as it is important to study the effect of nanoparticles on our health and how to control these effects

Vaccine delivery : with the help of nanoscience the researcher are working of better vaccine techniques like needless vaccine , and are also working on universal vaccines that can work for more than one strain (4)

Regenerative medicine : researchers believe that one day with the help of nanotechnology we will be able to regenerate our organs with the help of bone and neural engineering .

Nanotechnology has a vast number of applications ans scope in the field of medicine.

ENVIRONMENTAL PROTECTION

Over the years we have excessively polluted and destroyed our environment and its protection has been a challenge for us for hundreds of years , the upcoming development and enhancing technologies like mining , industries etc has been proven lethal to our climate but with the help of nanotechnology there is hope for the protection of our environment .

Oil spills : oil spills can be very dangerous for the water bodies as well as for the life inside of it , hundreds of aquatic life die every year because of oil spills the conventional methods are very time consuming and inadequate , nano based option is a alternative way to deal with oil spills after the deepwater horizon disaster in 2010 the researchers from state university of new York (SUNY) developed a nanogrid of

photocatalytic copper tungsten oxide nanoparticles , when they are struck on by light they break oil into biodegradable particles

Cleansing of air : carbon dioxide is the biggest threat to our environment and is increasing at an alarming rate because of the industrialization , the increased rate of CO₂ is resulting in global warming , as result the ice caps are melting and risking the life there , the CO₂ has to be separated from the waste gases and the conventional methods are very expensive and uses chemicals but because of nanotechnology this problem is also tackled , the researcers in Germany have fabricated an ultra thin nanoscale polymer film that filters out CO₂ it can easily capture the CO₂ from power plants etc

Cleaning of radioactive materials

Radioactive waste can have a very bad effect on life if not taken proper care of it can cause cancer , genetic mutations etc , but nanotechnology can deal with this problem too , the radioactive wastes can be removed by titanium nanoparticles that act as absorbents to remove wastes such as caesium and iodine from water bodies .

Water treatment :

With the help of nanotechnology the water bodies can be easily purified and the contaminants can be reduced and neutralized with the help of nanotubes , self enzyme nanoparticles etc , the physical and chemical contaminants can we easily sensed and detected by nanoparticles using photoelectrochemical analysis , the conventional methods are very time consuming and expensive whereas these methods are very cheap and easy to perform

So overall nanoparticles play a very important role in the pollution prevention and further harm to the environment (3)

Electronics and IT

Nanotechnology has helped revolutionize the electronics and IT sector resulting in smaller , faster and more efficient devices that are very portable is size and can store huge amount of data one of the best examples are ,

Transistors which is the basic building block of modern electronics with the help of nanoscience their sizes have gotten smaller and smaller and can store huge amount of data in a couple of years it is possible to have a small chip in which the entire memory of our computers can be stored .

Ultra HD display : with the help of quantum dots more efficient display and vibrant colouring can be observed in our television and desktop sets .

Nanoscience has excelled in other electron and computing products such as flexible , stretchable ,

foldable devices like electronic paper etc the products are highly efficient and smart , some other products include antimicrobial or antibacterial coatings on keyboards and smart phone screen , smart cards etc ,

All in all it is a very benefitting technology in the sector.

Skin care and cosmetics

It is believed that nanotechnology can help us reverse ageing in a cellular level but until that day comes there are other very important applications of nanoscience in skin care and cosmetics one of the most important being protection from sunlight , zinc oxide nanoparticles are used in sunscreen to protect us from the harmful UV rays from the sun and make them less greasy and transparent and make them more absorbable on the skin .

nanotechnology can result in major breakthroughs in the cosmetic industry in the future

Nano-hydroxyapatite is used in cosmetics and oral care for the treatment of hypersensitivity and enamel remineralization (5) and has also been considered safe for the use in oral products (6) , in 2019 the the EC updated the guidelines of the nanomaterials used in cosmetic fields and proper medical treatment and its safety check is done before the product is put in market . we can very soon expect nano based cosmetic products like sunscreens hair dyes with carbon nanoparticles having antidamaging effects , toothpastes , antiageing creams etc but safety considerations

have to be made first and foremost it is important to have medical testings of all the products .

Homeland security

Nanotechnology plays an important role in the national security , in the year 2000 the federal government established the national nanotechnology initiative (NNI) to promote the research of nanotechnology in a federal level the department of homeland security is conducting researches in this field related to explosives and explosive detection the area of technologies include the heterogeneity of explosives materials like novel synthesis routes using 3D porous materials that can result in controlling and tuning the size of particles in nanoscale according to the nano dashboard in 2021 all agencies combined are proposing to spend a total amount of 1723.2 million dollars on all program component area (PCA) (NNI initiatives) , all branches of the US are conducting nanotechnology research which includes defence advanced research project agencies (DARPA) office of naval research (ONR) army research officer (ARO) etc (7) nanoscience has various military applications with the help of carbon nanotubes and diamond films which have high strength to weight ratios than steel and is us to make lighter and strong armour and parts of aircraft vehicles , other applications include medical sensors , medical treatment , biological sensing etc

Researchers in the Georgia institute of technology believe that with the help of recently developed piezoelectric fibres someday will be able to generate their own electricity which would altogether eliminate the need of batteries ,(8) nanotech can also improve the communications on the battle field etc . this field is very beneficial for the defence and the homeland security branch and will enable a new class of production and weapons and could have great implications of the international security .

Roots Analysis

2.1 Company Profile

Roots Analysis Pvt. Ltd. is a business research and consultancy organisation focused on the pharmaceutical and biopharmaceutical industries. The research is primarily driven by an in-depth investigation addressing the following parameters: We are focused on delivering an informed and impartial opinion on important difficulties being addressed in the industry.

- R&D
- Market environment
- Commercial Prospects in the Future
- Concerns about the law
- Growth drivers for the region
- Possibilities and dangers

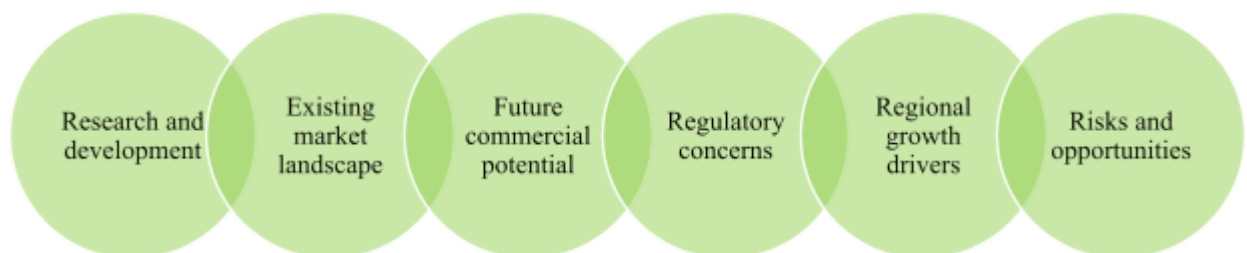


Figure 1.1 Primary Parameters for In-depth Analysis

Our company specialises in examining areas where there has been a shortage of quality research or where a more concentrated and in-depth grasp of the broader business is required. Apart from creating reports on certain topics, our firm also offers

research and consulting services to ensure that our clients receive the finest possible service.

The business reports cover a wide range of topics, including commercial success / potential, technology advancements, and a view based on possibilities and dangers.

The company focuses on the following domains in particular:

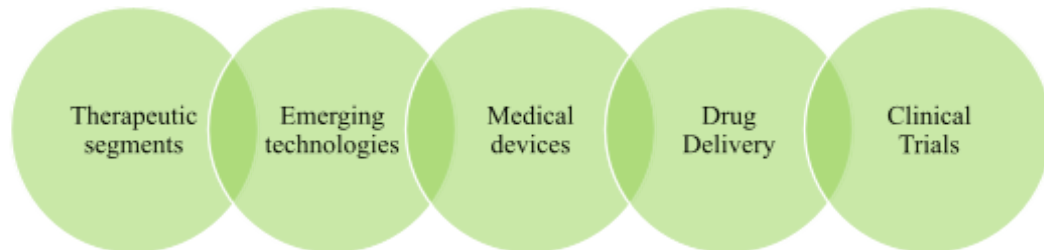


Figure 1.2 Focus Areas for Reports

- Therapeutic segments
- Emerging technologies
- Medical devices
- Drug Delivery
- Clinical Trials

We work with more than 400 clients worldwide, some of our clients are:

- Oxford biotherapeutics
- Repligen
- Sanofi
- Ambrx
- Johnson and johnson
- Celldex
- Novartis
- West
- Evonik
- Pfiser

We strongly rely on Primary research and Data Analytics:

- Problem/ Market definition
- Research Approach formulation

- Data procurement and preparation
- Data validation and normalization
- Market analysis and framework selection
- Unmet need identification
- Market landscape characterization
- Data presentation
- Post launch validation

Some of the analysis that our company specializes in are

- Patent analysis
- Publication analysis
- Competitive analysis
- Pipeline tracking
- Opportunity assessment
- Stakeholder need analysis
- Benchmarking analysis
- Valuation analysis
- Clinical trial analysis
- Kol analysis (key opinion analysis)
- Product life cycle analysis
- Deal tracking
- Unmet need analysis
- Academic grant analysis
- Therapeutic area assessment
- market expansion analysis
- Go to market strategy
- Regulatory landscape
- Cost saving analysis
- Competitive profiling
- Social media analysis
- Balance of trade analysis
- Reimbursement pathway
- Deal structure/ royalist analysis

- Investment analysis

Our company has published 400+ reports, 40+ major pharma market, 500+ clients, 50+ analytical framework, 100+ fortune 500 companies rely on us.

Our company loves what it does, we are budget friendly, most trusted consulting partner in industry.

Some of our reports include

- Single use downstream bio processing technology.
- Cell invasion and migration assay market
- RNAi Market : Therapeutic and technologies
- Global therapeutic vaccine market distribution by type of vaccine
- Prefilled syringes market by therapeutic area.
- Human Microbiome market
- Investor series: Opportunities in the cell and gene therapy market.
- 3D cell culture market
- Metabolomics service market
- Lypolization service market
- AI based drug discovery market
- CAR-T cell therapies
- Plant based meats
- Novel cardiovascular drug delivery devices
- Gene therapies and associated market by type of solutions
- Aptamers: Therapeutic, technologies and services market, distribution by application area.
- Companion diagnostic development services market.

2.2 Work Program

My internship at roots analysis began on 7th February 2022, during the entire month of may I was under the guidance of my manager Mrs Ankita khanna, I assisted my team mates with their individual projects.

The main objective of my work at that period of time was

- To make company profiles with the help of linkedin
- To make a comprehensive database including the information of the instances that were required
- To build a patent database and to sanitize the data and do its analysis
- To work on the publication module
- To build a PPT brochure for the project.
- To draft a word file for the abstract for the project.

After February I was shifted to the analysis team, my main objective in the team was to:

- Work on the simple modules namely- Patent Analysis, Publication Analysis, Key opinion leader, clinical trial analysis, partnerships and collaboration, Venture Capital funding , recent development analysis and so on.
- I worked on multiple projects and on multiple modules on a daily basis.
- My main job was to analyse the entire module and suggest and see if the module was giving valuable insights and information and whether or not the module can help in better decision making in the client point of view.
- So far ive worked on more than 15 different modules and more than 10 different projects.

The learning outcome has been enormous.

2.1. RESEARCH METHODOLOGY

Most of the data presented in this report has been gathered via secondary and primary research.

We have conducted interviews with experts in the area (academia, industry, medical practice and other associations) to solicit their opinions on emerging trends in the market. This is primarily useful for us to draw out our own opinion on how the market will shape up across different regions and technology segments. Where possible, the available data has been checked for accuracy from multiple sources of information.

The secondary sources of information include:

- Company's Annual reports
- Investor presentations
- SEC filings
- Industry databases
- News releases from company websites
- Government policy documents
- Industry analysts' views
- Research articles; Blogs; Press articles
- Company website



Figure 1.3 Secondary Sources Information

While the focus has been on providing a comprehensive view on the ongoing research, the report also provides an independent view on research and development and future commercial potential emerging in the industry. This opinion is solely based on our knowledge, research and understanding of the relevant market gathered from various secondary and primary sources of information.

2.4 Patent Analysis

Patent: A patent is type of an intellectual property that gives the owner the rights to his or her invention it is basically the exclusive rights of the product or the invention and prevents it from stealing or copyright, the permission of licensing may be given to the other parties and the rights could also be sold. There is also an expiration period of a patent and after that its protection ends and later on anyone can use it without resulting in the infringement of the patent. Most of the times a patent expires after 20 years.

Ownership: The owner of the patent has the right to decide who gets the ownership of the patent and who does not, it simple means that the invention or the product cannot be made, distributed or sold to anyone including public and any individual without the knowledge of the owner, or his/her consent

Importance: Filing a patent is not only important for the protection of the rights but also for the recognition of the inventor, it spreads knowledge and lets us know how much work is being done in a particular field. It helps us understand which topics are important and widely studies and which topics need more in depth licensing, Providing recognition motivates for more patents and gives us knowledge about further innovation.

Relevance of patents in business: It gives us an edge over the competition. It does not allow unauthorized use and copying and stealing, it also increases the financial return and the assets as a result the revenue increases and the company or the owner can enter in new market as the patents are licensed it increases the value of the invention as well as the business. Filing patents also has another advantage which is that it can help us obtain in funding.

Terminology

Abstract: The summary of the patent.

Application Date: The date on which the application for the patent was filed.

Publication Date: The date on which the patent was actually published.

Applicants: All the set of individuals who submitted the patent application.

Citation ID: All the ids where the scholarly cites have been done.

CPC Classification: The cooperative patent classification of the patents- As there as enormous amount of patents filed everyday it very important that they are classified in

certain groups so that we can tell which class they belong to just by looking at the classification of the code.

2.5 Funding And Investments

Funding: It is basically money required to start or run a business, it's a financial investment and the investment is done with the expectation that the money will gain and give us profit after a period of time. The investment can be done in a product, service, expansion, manufacture, marketing, inventory and so on. Startups usually do not prefer third party for investment as there is a chance of dilution of equity. The most important thing that we look during the analysis is that whether the funding instances actually the one that has been mentioned or not, this module helps us understand that whether or not the service or the product or the business is getting any sort of funding or not, having more funding simply means that the business is in demand.

Chapter Overview

Over the years, monetary assistance from angel investors, venture capitalists and funding schemes of various public and private organizations / funds, along with assistance from regulatory authorities, have allowed start-ups / small companies to further augment their R&D efforts related to DNA, RNA kits reagents. In this chapter, we have reviewed the various capital investments that have been made into companies focused on the development of DNA, RNA kits reagents. Further, it includes insights on how the overall market has evolved in terms of the investment activity. We have also highlighted the most active investors in this domain.

It is important to mention that the information presented in the chapter is completely factual and should not be misconstrued as a recommendation regarding any of the companies / products mentioned within. The funding instances presented in the following sections were identified from company websites, press releases and other publicly available databases.

TYPES OF FUNDING

There are several ways in which a company may receive financing. For the purpose of this analysis, we have considered the following types of funding:

▪ **Awards / Grants:** Awards / grants are usually provided by various government and nongovernment agencies, such as the Biomedical Advanced Research and Development Authority (BARDA), Defense Advanced Research Projects Agency (DARPA), European Union, Singapore Government and Bill & Melinda Gates Foundation. Generally, the amount invested into a company in the form of a grant is relatively less than that received through other types of funding; however, these funds enable small companies to execute very earlystage investigations and bring their ideas into mainstream R&D.

▪ **Seed Financing:** Seed funding is a type of an early investment that is made into a start-up to help initiate their operations. The amount invested at this stage is usually small and is used by the company to manage its expenses, such as costs associated with setting up of the firm and procuring the necessary infrastructure. It is important to mention that this is a highly risky investment from an investor's perspective. However, if the venture succeeds, returns on seed investments are considerably high, as even small investments generally translate into high equity shares in a company.

▪ **Venture Capital Investments:** Venture capital investments are a type of equity financing provided by one investor or a group of investors, to growing start-ups that are deemed to possess lucrative growth potential. In lieu of the money invested, investors acquire an equivalent stake in the company. The percentage equity share allotted to an investor depends upon the value of the company at the time of the investment. Through venture capital funding, companies can secure large capital amounts, which is essentially used to further augment their developmental activities. Progressive rounds of venture capital funding are denoted as Series A, Series B, Series C, Series D, Series E and so on. Series A funding refers to venture capital investments made into a company immediately after its seed funding round. It is worth mentioning that in each subsequent funding round, the capital invested also becomes larger, while the associated risks gradually decline. Venture capitalists profit at *exit events*, which refer to when the company that they have invested in, goes public and begins selling its shares on a stock exchange, or when the company is acquired by another company.

▪ **IPO / Secondary Offering:** An IPO refers to the instance wherein a private company offers its stocks / shares to the public for the first time. Such an offering is usually made by growing companies to fund the development of their product

candidates (*generally at a stage when they have begun to demonstrate significant commercial potential*), and to monetize investments of the investors who had financed the company during its early stages. After the successful closing of an IPO, a company is said to have gone public.

- **Debt Financing:** It refers to those instances where a company takes a loan from either a bank or an investor / a group of investors (*venture debt*) and is required to pay back the money with the interest due, irrespective of whether it is in profit or not.
- **Private Placement:** A private placement is a sale of stock shares or bonds to per-selected investors and institutions rather than on the open market. It is an alternative to an initial public offering (IPO) for a company seeking to raise capital for expansion.
- **Other Equity:** All other forms of equity investments captured during our research, including equities, warrants, and other rights, which could not be classified under the categories mentioned above, have been included in this category.
- **Others:** We consider funding instances wherein no detailed information on type of funding was available in the public domain.

2.6 MARKET OVERVIEW

Market overview as the name suggests is done to get the overview of the market and for decision making purposes to understand which markets to enter, which region to establish the market and how it will affect the growth of the company.

The overview can be product based or service based, the overview of the market is very important when we have to launch a new product, it provides the clients with all the information so that they can make an informed decision, that is whether the product will last long in the market, who are the key competitors.

This reduces our business risk of failure and helps us make informed decisions. We get to know the strength, weakness, threats and opportunities.

Forecasting the market is a key component for understanding the risk of failure, it helps us understand our past mistakes, what went wrong and why it went wrong and how can we improve our product or market, it gives us insights on how the key leaders work in the market what are their strategies and how they tend to be successful and in the top of the game. All in all it gives us an overview of the market, the potential, scope of the market and helps us In identifying the trends.

For the analysis part I have to understand and research on the topic very thoroughly and then I have to understand all the parameters in the overview to get insightful information and weather or not the analysis is valid or not or how can it be more insightful, as most of the times we work with enormous amount of data and it is very important to use this data in such a way that we can get the most of it in a very simple and precise way, most of the times the important parameters are not included and as part of my job is to give suggestions and comments to the team as to how they can improve and better the analysis so that just by looking at the analyses we

can get to know the key trends.

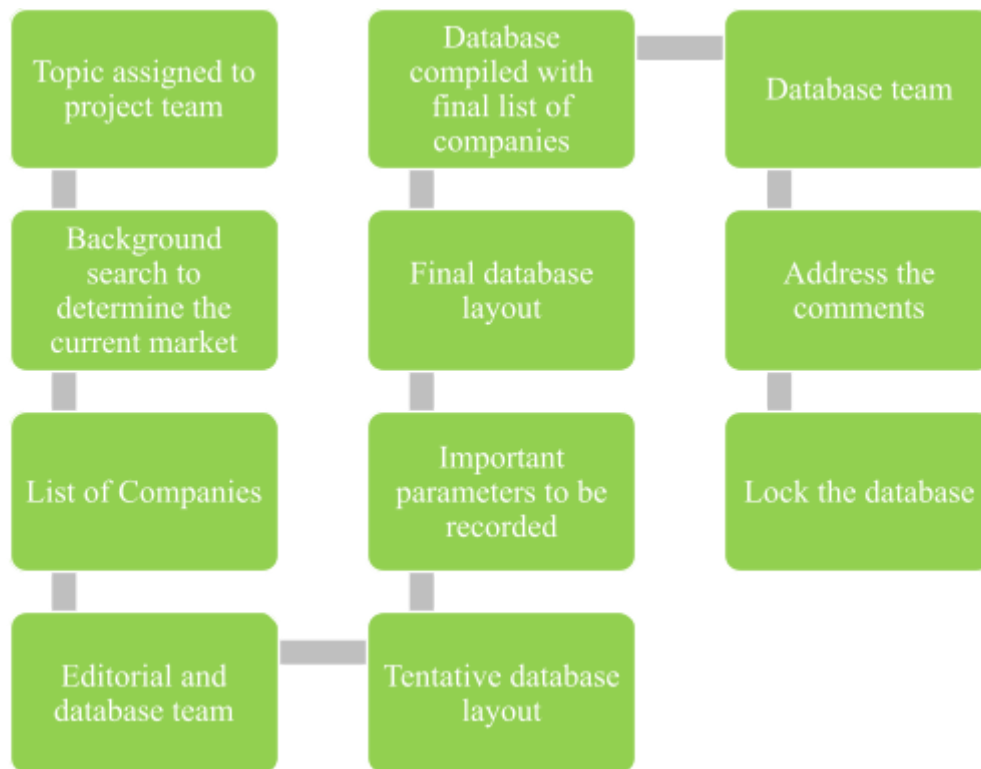


Figure 1.4 Workflow: Database building

2.7 LEARNING OUTCOME

During the course of my 4 month internship with roots analysis I got the opportunity to work in both project team and analysis team.

These 4 months have been a learning experience for me in so many ways, first and foremost this being my first corporate professional work environment I learned how to carry my self in such an environment, the work culture is very positive and the colleagues are very helpful and supporting there is a lot to learn from everyone the teams are highly motivating, I was able to complete daily and the weekly goals that had been assigned to me.

I got an in-depth learning about the pharmaceutical industry and its major players. I was able to develop excel skills and enhanced my research skill as well. After this course of my internship I can confidently say that I can interpret and analyze data in a very meaningful and productive manner.

Talking a little in depth about my experience, I was initially put in the project team where I assisted two of my co-workers. I worked in the project team for 1 month and learned the basics of how projects and reports were actually made, what was the entire process of it all. How to go about, I learned how to research and study about the project and how to sanitize the data as an enormous amount of data was available.

I worked on company profiles and learned how to make a better use of social media platforms like LinkedIn, I also worked on patent analysis and publication analysis followed by PPT brochure of the project and the word document, and in the entire process the entire team was very helpful and patient with me, thy focused more on the quality that the quantity, I also learned how to conduct an extensive secondary research. With these skills I will be able to observe, analyze, interpret and make decisions on various topics.

In march I was shifted to the analysis team, The analysis team analyzes all the modules that the project team makes, so as initially I just worked on one project in one month after moving to the analysis team I have analyzed modules of more than

20 projects, this not only enhanced my research skill but also enhanced my learning on a whole another level, as I am in my initial stages I just analyze the simple modules namely(patents, publication, market overview, clinical trial analysis, product competitive analysis, partnerships and collaborations, key opinion leaders, and so on) the main part of my job is to understand the project topic very thoroughly so that I am able to gin insightful information and analyze the data that has been put forth In front of me, everyone in the team has been very helpful and soon after a few months my goal is to be independent in few of the module.

These skills and the hands-on experience will certainly help me in my future endeavors, and for this I am very grateful to Roots Analysis and its entire team.

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