

Synthesis and characterization of Ferrite@semiconductor Multifunctional Nanoparticles For Bio-applications

Project report submitted in the partial fulfilment of the requirement for the

Degree of

BACHELOR OF TECHNOLOGY

IN

BIOTECHNOLOGY

Under the Supervision of

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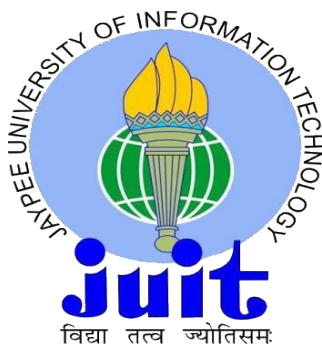
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May 2019

DECLARATION

I hereby declare that the work presented in this report entitled “**Synthesis and characterization of Ferrite@Semiconductor Multifunctional Nanoparticles for bioapplications**” in partial fulfillment of the requirements for the award of the degree of **Bachelor of Technology in Biotechnology** submitted in the Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from July 2018 to May 2019 under the supervision of **Dr. Ragini Raj Singh**. The matter embodied in the report has not been submitted for the award of any other degree or diploma.

Simran Sahni

Jandeep Singh Sethi

CERTIFICATE

This is to certify that the work reported in the report entitled “**Synthesis and Characterization of Ferrite@Semiconductor Multifunctional Nanoparticles For Bioapplications**” in partial fulfillment of the requirement for the award of the degree of **Bachelor of Technology in Biotechnology** submitted in the Department of Biotechnology and Bioinformatics, Jaypee University of Information Technology, Waknaghat is an authentic record of my own work carried out over a period from July 2018 to May 2019 under the supervision of **Dr. Ragini Raj Singh**. The matter embodied in the report has not been submitted for the award of any other degree or diploma.

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Abstract

This report work preferentially concerned with the synthesis and characterization of Ferrite@semiconductor multifunctional nanoparticles for bioapplication followed by testing of the inhibitory concentration.

The work has been systematically described in different chapters as follows:

Chapter 1 Contains an introduction of nanoparticles and their classification, a little insight of quantum dots and ferrites is also included.

Chapter 2 Describes the characterisation technique, principles and instrumentation and the methods used for their preparation.

Chapter 3 Results of characterization techniques and the inhibitory concentration have been discussed.

Chapter 4 Gives the conclusion of all the work done.

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List of Abbreviations

Abbreviation	Explanation
NPs	Nanoparticles
OD	Optical Density
K	Kelvin
Θ	Theta
Λ	Lambda
Π	Pi
CdS	Cadmium sulphide
QDs	Quantum Dots
Nm	Nanometer
QSP	Quantum Spot Detector
XRD	X-Ray Diffraction
FTIR	Fourier Transform Infrared
PL	Photoluminescence
Cm	Centimetre
Gm	Gram
RNA	Ribonucleic acid
DNA	Deoxyribonucleic acid
siRNA	Small interfering RNA

CHAPTER 1 - INTRODUCTION

1. Introduction

Science that concurrences with issue at the proportion of 10^{-9} of a meter (1 nm) is thought as technology. This investigation includes management of issue at nuclear and atomic scale. Nanoparticles – NPs are very little materials having size reaches from one to a hundred nm. NPs have one amongst a form physical and substance properties that are distinctive in respect to their mass structures due to their high surface territory and nanoscale estimate. It's properties like: High physical property, low weight, high electrical and heat properties and specific engaging properties (superparamagnetic conduct) and memorable electronic properties. Their optical properties are accounted for to be dependent on the scale, that grants varied hues due to retention within the noticeable space. Their reactivity, strength and totally different properties are likewise subject to their exceptional size, form and structure. Due to these qualities, they're acceptable for various business and family applications, that incorporate chemical process, imaging, medicative applications, vitality based mostly analysis, and ecological applications. Overwhelming metal NPs of lead, mercury and tin are accounted for to be thus inflexible and stable that their corruption isn't effectively getable, which might prompt varied natural toxicities. Supported variety of material there are varied sorts of nanoparticles like auriferous nanoparticles (Gold, Silver, Magnetic Nanoparticles), semiconductor nanoparticles (Quantum Dots), chemical compound nanoparticles (Carbon nanotubes, fullerenes) so on. Quantum dabs (QDs) are semiconductor nanocrystals with a core– shell structure and a measure that normally runs from a pair of to ten nm. Otherwise referred to as zero dimensional structures. a part of vitality levels in quantum dabs due to the quantum repression impact, semiconductor band hole increments with abatement in size of the nanocrystal.

1.1. Classification of Nanoparticles

Nanoparticles are generally divided into varied classes counting on their morphology, size and chemical properties. Supported physical and chemical characteristics, a number of the well-known categories of nanoparticles are given as below.

Fullerenes and CNTs speak to 2 noteworthy categories of carbon-based NPs. Fullerenes contain nanomaterial that are fabricated from globose empty pen, for instance, chemical phenomenon varieties of carbon. They created vital business enthusiasm due to their electrical conduction, prime quality, structure, lepton fondness, and flexibility (Astefanei et

al 2015). These materials have organized polygonal shape and hexangular carbon units, whereas each carbon is sp² hybridized.

Figure 1.1 demonstrates a little of the notable fullerenes comprising of C₆₀ and C₇₀ with the breadth of seven.114 and 7.648 nm, separately.

1.1.1. Carbon-based nanoparticles

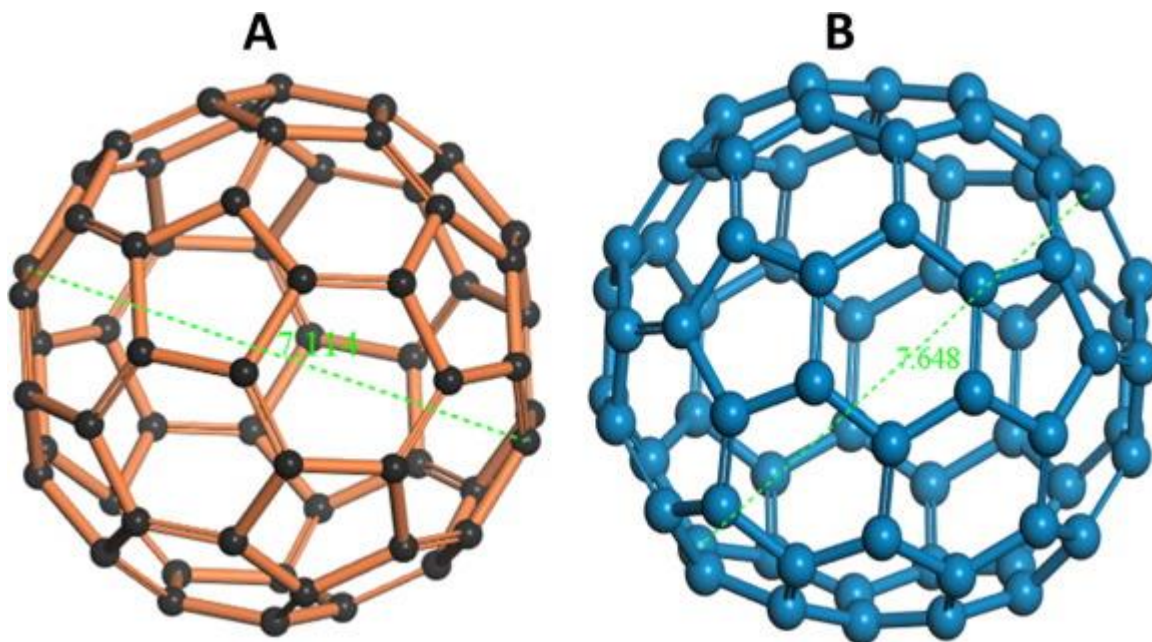


Figure 1.1: Fullerenes consisting of C₆₀ AND C₇₀

CNTs are long, rounded structure, as appeared in fig. 1.2, 1– a pair of nm in measure (Ibrahim, 2013). These will be anticipated as auriferous or conductive captivated with their breadth telicity (Aqel et al., 2012). These are essentially taking once to black lead sheet moving upon itself. The emotional sheets will be single, twofold or varied dividers and during this manner they named as single-walled (SWNTs), twofold walled (DWNTs) or multi-walled carbon nanotubes (MWNTs), separately. They're usually blending by legal instrument of carbon antecedents significantly the nuclear carbons, vaporized from black lead by optical maser or by electrical bend on to metal particles. Of late, they need been musical organization by means that of substance vapor statement (CVD) strategy (Elliott et al., 2013). Due to their fascinating physical, substance and mechanical qualities, these materials are utilized in immaculate structure moreover as in nanocomposites for a few business applications, for instance, fillers (Saeed and Khan, 2016, Saeed and Khan, 2014), adept gas

adsorbents for ecological correction (Ngoy et al., 2014), and as facilitate vehicle for varied inorganic and natural impetuses (Mabena et al., 2011)

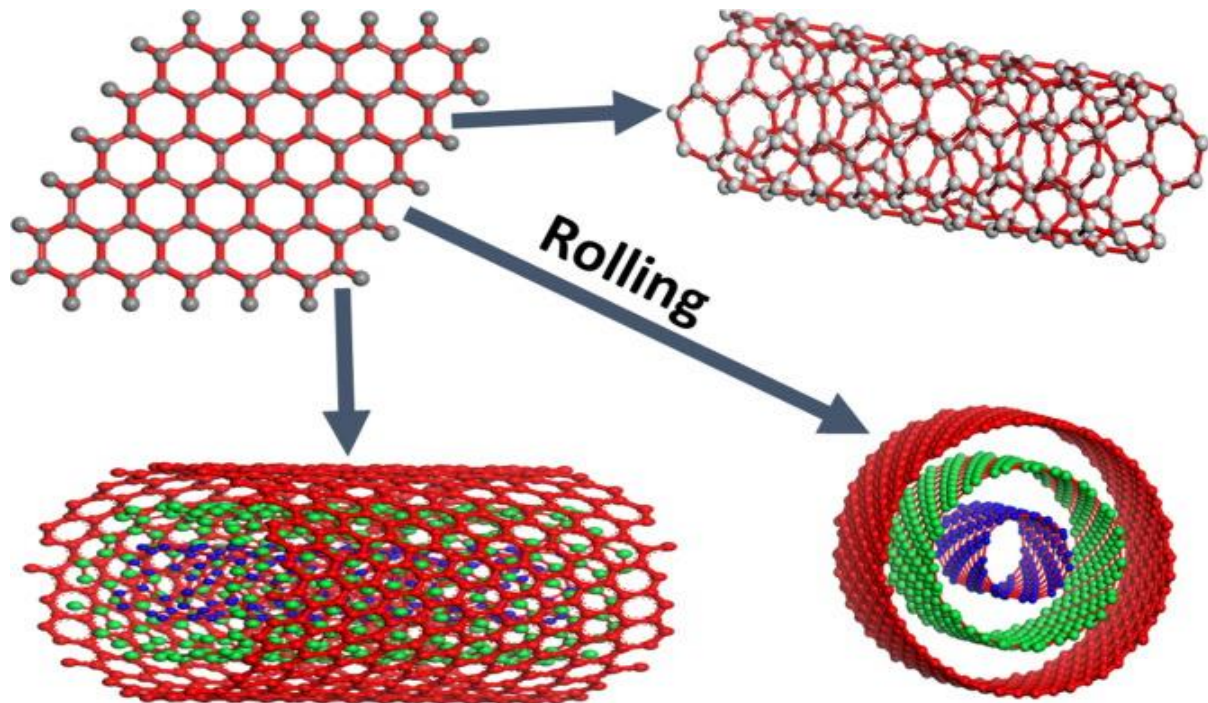


Figure 1.2: CNTs; Metallic or Semiconductor reliant

1.1.2. Metal Nanoparticles

Metal NPs are merely fabricated from the metals antecedents. due to sure as shooting understood restricted surface plasmon reverberation (LSPR) qualities, these NPs have fascinating optoelectrical properties. NPs of the salt and honorable metals for instance atomic number 29, Ag associate degreed Au have an expansive assimilation band within the clear zone of the magnetic attraction sun hopped-up vary. The aspect, size and form controlled mix of metal NPs is important in gift day harm edge materials (Dreaden et al., 2012). Due to their progressed optical properties, metal NPs discover applications in several analysis regions. Gold NPs covering is mostly utilised for the testing of SEM, to upgrade the electronic stream, that helps in obtaining nice SEM footage. There are varied totally different applications, that are deeply talked concerning in applications space of this audit.

1.1.3 Ceramics Nanoparticle:

Ceramic ware production NPs are inorganic non-metallic solids, musical organization through heat and progressive cooling. They'll be found in hazy, crystalline, thick,

semipermeable or empty structures (Sigmund et al., 2006). During this manner, these NPs have gotten unimaginable thought of scientists due to their utilization in applications, for instance, catalysis, photocatalysis, photo degradation of colours, and imaging applications. (Thomas et al., 2015).

1.1.3. Semiconductor Nanoparticles

Semiconductor materials have properties among metals and non metals and on these lines they found totally different applications within the writing due to this property (Ali et al., 2017, Khan et al., 2017a). Semiconductor NPs have wide bandgaps and consequently incontestable crucial adjustment in their properties with bandgap standardization. On these lines, they're vital materials in photo catalysis, photograph optics and electronic gadgets (Sun, 2000). For example, assortment of semiconductor NPs are found significantly adept in water half applications, because of their acceptable bandgap and bandedge positions (Hisatomi et al., 2014).

1.1.4. Chemical Compound Nanoparticles

These are sometimes natural based mostly NPs and within the writing a novel term polymernanoparticle (PNP) mixture utilised for it. They're usually nanospheres or nanocapsular wrought (Mansha et al., 2017). The previous are framework particles whose general mass is often robust and totally different atoms are adsorbable at the external limit of the spherical surface. Within the last case the robust mass is exemplified within the molecule altogether (Rao and Geckeler, 2011). The PNPs are promptly functionalize and during this method discover packs of utilizations within the writing (AbdEllah and Abouelmagd, 2016, Abouelmagd et al., 2016).

1.1.6.Lipid-Based Nanoparticles

These NPs contain lipid moieties and viably utilizing in varied medical specialty applications. By and enormous, a lipid NP is often circular with breadth extending from ten to a thousand nm. Like chemical compound NPs, lipid NPs have a robust center fabricated from lipid and a lattice contains solvent lipotropic particles. Surfactants or emulsifiers

balanced out the outer center of those NPs (Rawat et al., 2011). lipid technology (Mashaghi et al., 2013) is associate degree exceptional field, that center the structuring and combination of lipid NPs for various applications, for instance, sedate bearers and conveyance (Puri et al., 2009) and ribonucleic acid discharge in malignant growth treatment (Gujrati et al., 2014).

1.2 Magnetic Nanoparticles

Magnetic nanoparticles engaging nanoparticles are nanomaterials comprise of attractive parts, for instance, iron, nickel, cobalt, chromium, manganese, gadolinium, and their substance mixes. engaging nanoparticles are superparamagnetic because of their nanoscale estimate, giving unimaginable prospects in associate degree assortment of uses in their exposed structure or lined with a surface covering and utilitarian gatherings picked for specific employments. Significantly, primary solid solution nanoparticles are the foremost investigated engaging nanoparticles, which might be improbably distended by bunching of assorted individual superparamagnetic nanoparticles into teams to form engaging dots. Engaging nanoparticles will be specific connected to associate degree utilitarian particles and modify transportation to a centered on space underneath an outdoor attractive field from a magnet or changeless magnet. Thus on forestall total and limit the cooperation of the particles with the framework condition, surface covering can be needed. The skin of primary solid solution nanoparticles is frequently modified by surfactants, silica, silicones, or chemical element corrosive subsidiaries to make their strength in arrangement. Once all is alleged in done, lined engaging nanoparticles are usually utilised in an exceedingly few therapeutic applications, for instance, cell disconnection, bioassay, analytic testing and medicine conveyance.

1.3 Properties

1.3.1. Magnetic Properties

The properties of engaging nanoparticles depend on the union technique and substance structure. As a rule, the engaging nanoparticles run from one to a hundred nm in size and might show superparamagnetism. Superparamagnetism is led to by warm impacts that the nice and cozy changes are sufficiently able to sharply demagnetize a recently soaked get together; thus, these particles have zero coercivity and don't have any physical phenomenon.

During this specific, associate degree outer engaging field will charge the nanoparticles with lots larger attractive unprotectedness. At the purpose once the sector is expelled, engaging nanoparticles show no polarization. This property will be useful for controlled treatment and centered on medication conveyance.

1.3.2. Magnetocaloric Effect

Some attractive materials heat up once they are set in a pretty field and chill off when they are expelled from an attractive field, that is characterized because the generator caloric impact (MCE). Engaging nanoparticles provides a promising possibility in distinction to customary mass materials because of their molecule estimate subordinate superparamagnetic highlights. Moreover, the substantial surface zone in engaging nanoparticles will probably provide higher heat trade the surrounding condition. Via cautious arrange of center shell structures, it's conceivable to manage the heat trade between the engaging nanoparticles and also the encompassing lattice, that provides a conceivable methodology to rising treatment advancements, for instance, physiological condition.

1.4. Applications

1.4.1. Magnetic separation

In an exceedingly medical specialty report, Isolation and division of specific particles as well as DNAs, proteins, and cells are necessities in several fields of biosciences and biotechnology. Among totally different bio-separation ways, engaging nanoparticles based mostly bio-separation is for the foremost half archived and customarily utilised due to its exceptional attractive detachment state of mind and promising productivity. In the fig. 1.3, the natural particles are named by engaging nanoparticles colloids associate degreed at that time exposed to division by an outer attractive field, which could be connected for cell detachment, macromolecule cleanup, RNA/DNA extraction, and immunoprecipitation.

Attractive nanoparticles particles, for instance, globules are generally utilised for division and purging of cells and biomolecules, due to their very little size, promising partition disposition, and nice dispersibility. One amongst the patterns during this branch of information is that the engaging partition utilizing antibodies conjugated with dots to relinquish passing precise antibodies that may expressly tie to their coordinative antigens on the skin of the centered on locales.

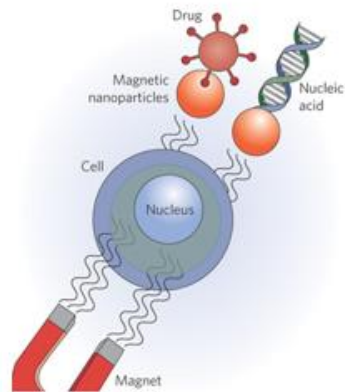


Figure1.3: Magnetic Nanoparticles

1.4.2. Medical Speciality

Non-obtrusive imaging techniques are created by marking immature microorganisms utilizing engaging nanoparticles. Among them, resonance Imaging (MRI) is generally utilised as symptomatic apparatuses to exhibit a high special goals and extraordinary anatomical detail to image the structure and capability of tissues. Some types of engaging nanoparticles are created to boost differentiate specialists in tomography imaging, with crucial blessings of improved affectability, nice biocompatibility and ready discovery at moderate focuses. 1.4.3. Sensors varied types of engaging nanoparticles-based biosensors are surface functionalized to understand specific atomic focuses, due to their one amongst a form engaging properties that don't seem to be found in natural frameworks. Due to varied structure, estimate and engaging properties, engaging nanoparticles will be utilised in associate degree assortment of instruments and organizations for biosensing with an improvement of affectability and also the soundness.

1.4.3. Sensors

Numerous sorts of attractive nanoparticles-based biosensors have been surface functionalized to perceive explicit atomic focuses, because of their one of a kind attractive properties which are not found in natural frameworks. Because of various structure, estimate and attractive properties, attractive nanoparticles can be utilized in an assortment of instruments and organizations for biosensing with an improvement of affectability and the soundness.

1.4.4. Drug delivery

Engaging nanoparticles are created and connected in confined medication conveyance to tumors. [Fig. 1.4]. The engaging nanoparticles initially move as a bearer of the medication, that is appended to its external surface or slice within the covering. Once the medication-lined particles are brought into the circulation system of the patient, a pretty field slope is created by solid changeless magnet to carry the particles at the centered on district. Also, engaging nanoparticles lined with a medicine may well be infused intravenously, transported, and command at centered locales that build them exceptionally encouraging framework for medication conveyance.

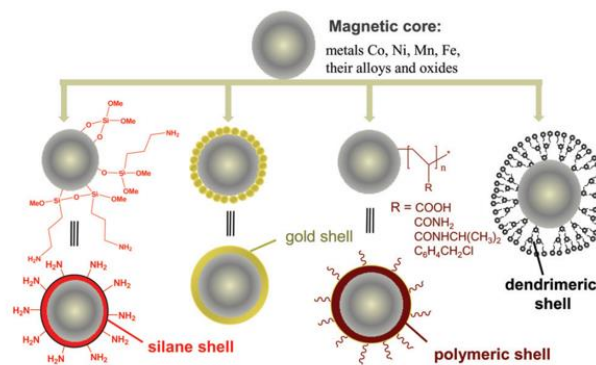


Figure 1.4 : Magnetic Core and subdivisions

1.4.5. Medical Aid

Engaging nanoparticles are created and connected in confined medication conveyance to tumors. The engaging nanoparticles initially move as a bearer of the medication, that are appended to its external surface or slice within the covering. Once the medication-lined particles are brought into the circulation system of the patient, a pretty field slope is created by solid changeless magnet to carry the particles at the centered on district. Also, engaging nanoparticles lined with a medicine may well be infused intravenously, transported, and command at centered locales that build them exceptionally encouraging framework for medication conveyance.

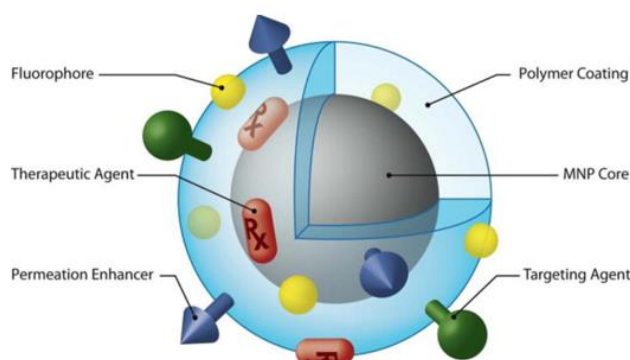


Figure 1.5: Super paramagnetic nanoparticles and their application in therapy.

1.5. Multimodal Fluorescent-Magnetic Nanoparticles

The structure and creation of materials that at the identical time contain quite one helpful phase, alleged multifunctional materials, could be a functioning exploration region with the chance to have an effect on a large scope of innovative applications. Among associate degree assortment of conceivable structure squares, mixture nanocrystals have incontestable to be good for manufacturing higher-request styles either in capricious or requested congregations. Specifically, co-gathering 2 types of nanocrystals with clear properties into larger mixture particles, significantly at the mesoscopic scale, offers the chance of delivering new categories of nanoparticles (that is, supernanoparticles (SPs)) with lots of consolidated properties, at the identical time maintaining the mixture plan of their structure squares. Besides, orchestrating SPs with well-characterized inward structures, albeit testing, can be basic in making novel properties. Specifically, magneto-fluorescent particles are perceived as a rising category of materials that have potential in innovative applications. To fully perceive their potential and to boost their presentation, the incidental to structure criteria ought to be at the identical time satisfied: uniform and tunable sizes, high engaging substance stacking for synergistic attractive properties, boosted stacking of fluorophores at the surface for a complicated visible light signal, long-standing time mixture security and a versatile surface utility for the fluctuated stipulations of assorted applications, significantly in science. An easy and versatile built technique provides the additional advantage of a moderately fast materials creation. within the previous decade, abundant effort has been committed to making built systems for the manufacture of such magneto-fluorescent materials, as well as heterostructure gem development , co-exemplification into natural structures (for instance, oil bead, lipid particle and sq. co-polymer) or inorganic materials (for instance, silica) , layout based mostly combination by means that of either substance holding or physical association.

1.6. Ferrites

Ferrites are engaging ceramic ware production containing iron chemical compound as a motivating constituent in it. It's presently somewhere within the vary of a protracted time since ferrites appeared as a major new category of engaging materials. These are presently terribly settled gathering of engaging materials. Thesedays' ferrites are utilised in an exceedingly extremely wide scope of uses, and have contributed well to the advances in gadgets. Within the territory of recent materials, ferrites with permeableness up to thirty thousand and management ferrites for frequencies up to ten megahertz are created accessible monetarily. Despite the actual fact that, upgrades and advancements persevere occurring; varied new applications, hypotheses and arrangement innovations are without delay a piece current in field of ferrites. Ferrites are iron based mostly oxides with innovatively charming engaging properties, creating them a visible classification in engaging materials. The primary solid solution particles in nano-routine with crucial distinction in physical properties provide a lot of most popular viewpoint over the mass ferrites. With relevance the quickly mounting field of technology, primary solid solution nano particles are the middle of broad analysis regarding their across the board applications, be it medical specialty, innovative or mechanical. Nano crystalline particles of engaging materials show considerably upgraded attractive properties. The unit of the mineral primary solid solution is framed by multiplying the face centered blocky element sub grid on each one of the 3 measurements. During this course of action sixty four tetrahedral or A-sites and thirty two octahedral or B-destinations are created within the unit. In stoichio metric spinels simply eight A-destinations and sixteen B-locales are stuffed by power progress metal particles. The centralizations of metallic element, ferrous and substituted metal particles and their appropriation over tetrahedral and octahedral destinations assume a vital job choose their engaging and electronic properties. In typical spinels, all the A-locales are concerned by power modification metal particles whereas in backwards spinels; the divalent particles possess B-destinations. In scattered spinels the power particles are offered on each associate degree and B-sites. the ordinary and reverse spinels are a pair of boundaries between that the ion dissemination could fluctuate. At the purpose once the beginning of the unit is taken at the focuses of symmetry, the element point parameter 'u' (the separation between the oxygen particle and also the essence of the 3D sq. edge on the solid form corner to corner of the mineral sub cell) has good qualities zero.375 (3/8) and zero.250 (1/4) singly, for a perfect blocky shut stuffed game arrange of element particles. For this example the octahedral ion ion separation or bond length is one.155 occasions larger than the tetrahedral bond length. A deviation from the proper

structure happens once element is dislodged on [111] course to suit the constituent cations, the tetrahedral website with littler volume grows to the impairment of the octahedral site associate degree afterwards u an esteem a lot of noteworthy than 0.375. Thus on management the area of ferrite's applications, the examination of ion conveyance on associate degree and B locales and element point parameter u, is mostly vital. Ferrites are created out of iron chemical compound as their primary constituent and metal oxides. Contingent the valuable stone structure, ferrites are of following kinds.

1.6.1. Spinel Ferrite

Spinel ferrites are delineate by the substance equation MFe_2O_4 wherever M represents power metal particles. The valuable stone structure of mineral primary solid solution has 2 opening destinations to be specific tetrahedral (A) and octahedral [B]. Associate degree assortment of cations will oblige at tetrahedral A website and octahedral B site empowering wide range within the properties of ferrites. M will be supplanted by different power metal particles and that we will have range of mineral ferrites. Fe^{3+} particles will be supplanted by different powerfulness particles like Al^{3+} , Ga^{3+} so on. Fe^{3+} particles will likewise be supplanted by mixture of power and power particle.

1.6.2. Garnet

The substance equation for ferromagnetic garnet is $Me_3Fe_5O_{12}$ wherever, Pine Tree State could be a powerfulness particle, for instance, uncommon earth or Y. The unit is blocky and contains eight atoms of $Me_3Fe_5O_{12}$ for instance (160 iotas). The metal particles are spread quite 3 sorts of locales. The Pine Tree State particles possess the dodecahedral locales (called c destinations), wherever they're encompassed by eight element particles, the Fe^{3+} particles circulated over the tetrahedral and octahedral locales within the proportion 3:2. As on account of spinels, the engaging arrangement results from super trade collaboration by means that of the mediating element particles, and also the cooperation is needed to be a lot of outstanding for the shorter the Me-O separation and nearer the Me-O-Me edge is to 1800. On this premise it's reasoned that the cooperation between the d and a cations are usually solid (both negative). The all out engaging minutes on 'an' and 'd' particles are adjusted parallel and also the minutes on the c-particles are antiparallel to those on the d-particle. during this manner for the formula $(3M_2O_3)_c (2Fe_2O_3)_a (2Fe_2O_3)_d$ the course of action is $6Fe_d$, $4Fe_d$, $6Mc$. the web engaging minute m (in nuclear physicist magneto motive force unit per unit

recipe) is $m = 6mc - (6md-4ma) = 6mc - 10 \mu B$ one.1 assumptive a pretty exposure of $5 \mu B$ per Fe particle, as way because the unit equation $M_3Fe_5O_{12}$ condition one.1 progresses toward turning into $m = (3mC - 5 \mu B)$ one.2 where, M_c is that the engaging minute per Pine Tree State particle.

1.6.3.Orthoferrites

Ortho ferrites have the final equation Pine Tree State $MeFeO_3$ wherever Me is an in depth powerfulness metal particle like uncommon earth particle or Y. Ortho-ferrites have the final formula $MeFeO_3$, where, Pine Tree State could be a substantial powerfulness metal particle, for instance, uncommon earth particle or Y. They solidify in associate degree exceedingly twisted perovskite structure with an orthorhombic unit. These ortho-ferrites demonstrate a frail magnetism that has been attributable to the insufficient inclination within the arrangement of 2 enemies of ferromagnetically coupled cross sections. The inclination purpose is of the request of 10-2 rad nevertheless is equal to gift a touch internet magnetism minute opposite to the magnetic attraction hub. The course of flip introduction of the Fe particle in $HOFeO_3$ and $ErFeO_3$ has been tentatively set (9) at temperature and discovered to be parallel to the (100) hub on delivery down the temperature the turn pivot turns, and at 1.25K the bearing is (001) for $HOFeO_3$ and (110) for $ErFeO_3$. The flip minute on the uncommon earth particle gets requested at a way lower Louis Eugene Felix Neel temperature [6.5 K for $HOFeO_3$ and 4.3 K or $ErFeO_3$].

1.6.4.Hexagonal Ferrites

There are varied ferrites that form in hexagonal structure, and a few of them have exaggerated vital innovative significance as these days. These ferrites are any sub-ordered into M, W, Y, Z and U mixes of these have distinctive, but connected, gem structures. The M mixes have the smallest amount advanced structure. Metallic element primary solid solution, the notable onerous ferrites, encompasses a place with this category. These mixes have the final equation $MFe_{12}O_{19}$ wherever M could be a power particle of an in depth ionic sweep, for instance, Ba^{2+} , Sr^{2+} , or Pb^{2+} . some mixes with powerfulness M (for example $La+Al^{3+}$, Ga^{3+} , Cr^{3+} , Fe^{3+}) are in addition legendary. In these, driving iron for every equation unit is offered as Fe^{2+} to require into thought the charge remuneration. The valuable stone structure of metallic element primary solid solution is hexangular with the unit created of 2 unit formulae. The structure is known with the mineral structure within which the element cross

section, f.c.c., comprise of a progression of hexangular layers of element lying opposite to the (111) course.

1.7.Quantum dots

Nanocrystals within which alleged quantum impacts happen due to their improbably very little distance across (in the scope of a pair of nanometers) are referred to as quantum spots. These don't comprise of a standardized material, nevertheless depict a full category of materials. Quantum impacts cause improbably intriguing optical, engaging and electronic properties in nanocrystals. For example, they'll sparkle (fluoresce) with the guide of sunshine, provide power altogether respects proficiently or fill in as a super-little memory or processor parts in IT. With a size of around 1-100 nm, quantum spots comprise for the foremost a part of semiconductor materials. They're fabricated from it's doable that one or varied materials, that pursue a development rule of center and shell. Frequently varied materials are utilised for the middle and shell, whereby some covering layers are in addition conceivable. Each the electronic and optical properties of the quantum specks will be positively balanced with this reputed center shell structures that build them intriguing for varied applications. With the expectation of complimentary auriferous quantum specks there's a theoretic hazard that they'll self-touch off seeable of their substantial surface region. Be that because it could, as they're usually simply ready established in fluids or plastics and utilised in exceptionally very little amounts, explosive ignition is all around not possible. There are 3 principle sorts of Quantum specks:

1 .III-V-semiconductors: fabricated from elements of main cluster III of the tabular array of the weather (boron, aluminum, gallium, indium) and main cluster V (nitrogen, phosphorus, arsenic, antimony, bismuth)

2.II-VI- semiconductors: fabricated from parts of transition metal cluster II (zinc, cadmium) and main cluster VI (oxygen, sulphur, selenium, tellurium)

3.Silicon (Si), the quality material of the semiconductor and chip trade one.

1.7.1. Optical Applications

The high elimination constant of a quantum dab makes it ideal for optical employments. Quantum specks of extraordinarily high caliber will be good for applications in optical secret writing and multiplexing due to their tight outflow spectra and wide excitation profiles.

1.7.1.1. Light Emitting Diodes

Quantum dot light emitting diodes (QD-LED) and 'QD-White LED' are exceptionally valuable whereas delivering the showcases for electronic gadgets since they manufacture light in deeply specific mathematician circulations. QD-LED [fig. 1.6] displays will render hues altogether respects exactly and utilize significantly less power than typical displays.

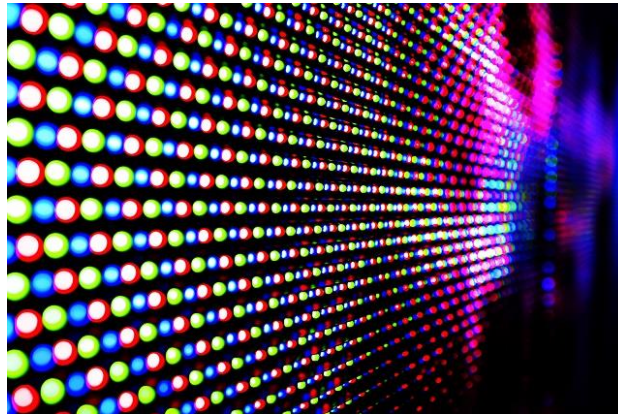


Figure1.6: Light emitting diode.

1.7.1.2. Photodetectors

Quantum spot photodetectors (QDPs) will be created from typical single-crystalline semiconductors or arrangement ready. Arrangement ready QDPs are good for the coordination of some substrates and to be used in incorporated circuits. These mixture QDPs discover use in machine vision, observation, spectrum analysis and trendy examination.

1.7.1.3. Photovoltaics

Quantum speck daylight based mostly cells are considerably a lot of financially savvy once contrasted with their atomic number 14 sun based cells partners. Quantum speck sun based mostly cells will be delivered utilizing basic artificial responses and might spare collecting prices therefore. Operational proficiency is likewise hugely improved by utilizing quantum specks. In customary atomic number 14 p-n intersection sun hopped-up cells, once a gauge boson with vitality not precisely the bandgap of atomic number 14 hits the sun hopped-up cell it's transmitted and doesn't augment the ability yield. This outcomes in associate degree exchange off in arrange, if the bandgap is lower all the lot of approaching photons will energize electrons (which means that the next current) nevertheless the electrons have lower vitality (hence lower voltage) and also the different method around for a higher bandgap.

theoretic pinnacle sun familiarised proficiency for a atomic number 14 p-n sun hopped-up cell is 33.7%. Quantum specks can give a motivating increment in effectiveness, by utilizing dabs of differing sizes high of 1 another with the most important band holes on top. Approaching gauge bosons are going to be transmitted till achieving a layer with a bandgap littler than the photon vitality. With enough layers each gauge boson can energize associate degree lepton with a bandgap close to its very own vitality and consequently squander a touch live of vitality. At the purpose once the number of layers approaches unendingness, the productivity approaches a theoretic physics brink of eighty six.

1.7.1.4. Biological Applications

The foremost recent age of quantum specks has extraordinary potential to be used in natural investigation applications. They're usually accustomed ruminant intracellular procedures, neoplasm focusing, in vivo perception of cell dealing, medical specialty and cell imaging at high goals. Quantum dabs have incontestable to be much better than normal natural colors because of their high quantum yield; photo stability and tunable emanation vary. They're multiple times a lot of steady and multiple times more splendid than customary fluorescent colours. The exceptional photostability displayed by quantum spots build them good to be used in ultra-touchy cell imaging. This allows some consecutive central plane footage to be reassembled into three-dimensional pictures at extraordinarily high goals. Quantum dabs will target specific cells or proteins utilizing peptides, antibodies or ligands and afterwards saw to look at the target macromolecule or the conduct of the cells. Specialists have discovered that quantum spots are way superior at conveyance the siRNA quality hushing equipment to focus on cells than nowadays utilised techniques. In progress examinations have planned adding lightweight initiated particles to anti-toxins to battle the increasing issue of medication safe diseases. The types of artificial compounds created once lightweight has hit the quantum speck will be adjusted by ever-changing the scale. By ever-changing this Researchers at the University of Colorado have created anti-infection agents that with quantum specks discharge a superoxide macromolecule. This anxieties the microscopic organisms, creating it increasingly helpless against anti-toxins that it had recently been immune to. This might be unthinkable vital for the long run, with the live of medication safe contaminations perpetually rising.

1.7.1.5. In the Long Term What Holds For Quantum Dots

Quantum spots are zero dimensional and show a lot of honed thickness of states than structures of upper measurements. This clarifies their nice optical and transport properties, that are as of currently being targeted for potential uses in intensifiers, organic sensors and diode lasers. The wide scope of constant uses of quantum spots within the field of science is relied upon to be useful in several analysis teaches, for instance, malignancy metastasis, embryogenesis, WBC medical specialty and immature being medicine. in a while specialists in addition trust that quantum dabs will be utilised because the inorganic fluorophore in intra-usable neoplasm location once performed utilizing visible light spectrum analysis.

1.8. Core@Shell Structures

The structure of the instance whose portrayal we want to perform could be a center shell structure we've taken the inward center that is a primary solid solution and also the shell we have settled on is a semiconductor as appeared in fig. 1.7.

NPs are created out of 3 layers for instance the middle, shell layer and surface layer.

(a) The center that is that the focal phase of the NP.

(b) The shell layer, that is by artificial means not the identical because the center altogether viewpoints.

(c) The surface layer, which could be functionalized with associate degree assortment of very little particles like metal particles, surfactants and polymers.

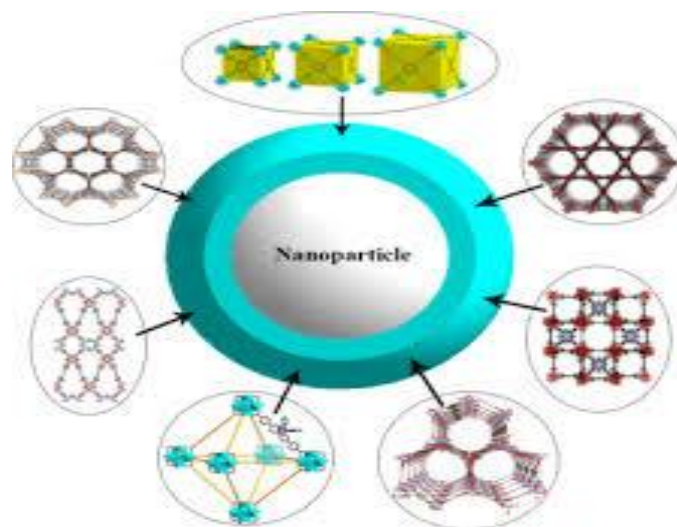


Figure 1.7: Core shell structure

1.9. Methods of Synthesis of Nanoparticles

In general, top-down and bottom-up are the 2 main approaches for synthesis.

1.9.1. Top-down: size reduction from bulk materials.

These courses are incorporated into the standard robust – state handling of the materials. This course relies with the mass material and makes it littler, during this method separating larger particles by the employment of physical procedures like pulverizing, process or granulating. Unremarkably this course isn't acceptable for preparing systematically fashioned materials, and it's onerous to acknowledge exceptionally very little particles even with high vitality utilization.

1.9.2. Bottom up: material mix from nuclear dimension.

Approach alludes to the event of a cloth from the base: iota by-particle, atom by-atom or cluster by-bunch. This course is all the lot of often utilised for designing the overwhelming majority of the nano-scale materials with the capability to form a standardized size, form and conveyance. It viably covers compound combination and resolutely controlled the response to repress any molecule development. In spite of the actual fact that the bottom up methodology is simply the identical previous issue new, it assumes a major job within the creation and making ready of nanostructures and nanomaterials. Combination of nanoparticles to possess a superior authority over particles live appropriation, morphology, virtue, quantity and quality, by utilizing condition friendly economical procedures has faithfully been a check for the analysts.

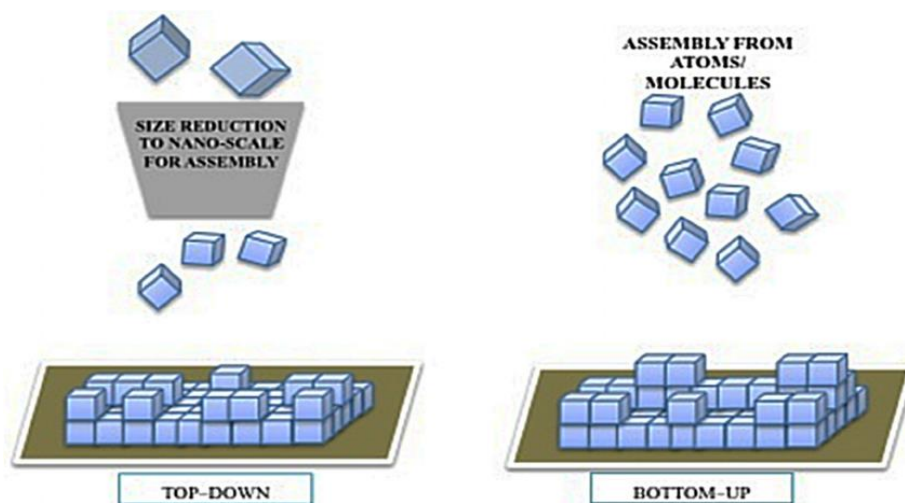


Figure 1.8: Top Down and Bottom up Synthesis

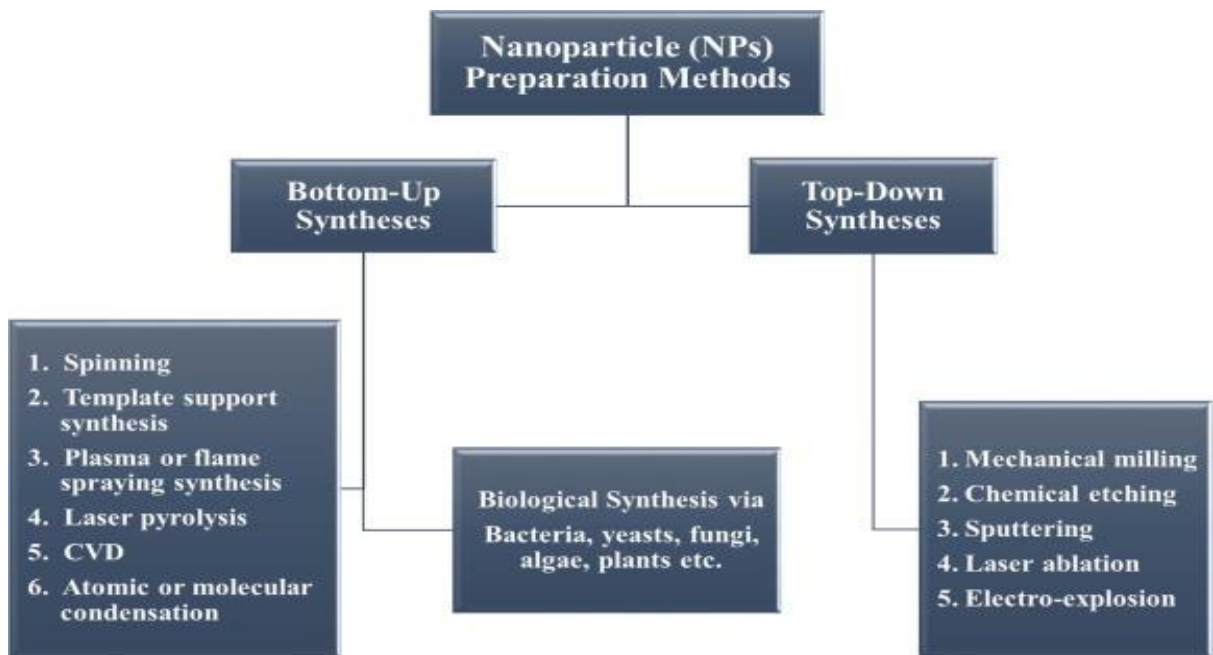


Figure 1.9: Synthesis techniques for nanoparticles.

CHAPTER 2 – EXPERIMENTAL DETAILS

2. Experimental Details

2.1. Characterization of samples:

Portrayal, once utilized in materials science, eludes to the expansive and general procedure by that a material's structure and properties are examined and calculable. It's an important procedure within the field of materials science, while not that no logical comprehension of planning materials may well be revealed. The extent of the term often contrasts; some definitions limit the term's utilization to procedures that give some thought to the small structure and properties of materials, whereas others utilize the term to suggest to any materials examination method as well as plainly visible ways, for instance, mechanical testing, heat investigation and thickness computation. The scale of the structures saw in materials portrayal ranges from angstroms, for instance, within the imaging of individual iotas and artificial bonds, up to centimeters, for instance, within the imaging of coarse grain structures in metals.

2.1.1 X-ray diffraction

X - ray diffraction technique is that the commonest and economical methodology for the determination of structure and crystallinity and material identification. XRD is associate degree apt methodology to look at whether or not a resultant material has amorphous or crystalline nature. Crystalline phases will be known by simply comparison the interplanar distance 'd' values obtained from XRD knowledge with the basic data in Joint Committee on Powder optical phenomenon Standards (JCPDS). Principle: X-ray diffraction relies on constructive interference of monochromatic X-rays from a crystalline sample. The X-rays, generated by a electron beam tube are filtered to provide monochromatic radiation, collimated and directed towards the sample. X-ray primarily act with electrons in atoms, collide and a few photons from the incident beam are deflected far from original. The X-rays interfere constructively and destructively manufacturing a optical phenomenon pattern on the detector. The incident X-ray radiation produces a full general peak if their reflections from the assorted planes interfered constructively. The interference is constructive, once the section shift could be a multiple of 2π , this condition will be expressed by Bragg's law

$$n \lambda = 2d \sin \theta \quad (1)$$

wherever, n could be a range, λ is that the wavelength of incidence wave, d is that the dividing between the planes within the nuclear cross section and Θ is the edge between the episode beam and also the dispersing planes. A run of the mill powder X - beam diffractometer includes of a wellspring of radiation, a monochromator to choose the wavelength, cuts to change the state of the pillar, associate degree example and a symbol. A direction finder is used for fine modification of the instance and also the surveyor positions. The direction finder part underpins the instance and indicator, allowing actual development. The supply X - beams contains some segments; the foremost well-known being $K\alpha$ and $K\beta$. the actual wavelengths are traditional for the target material (Cu, Fe, Mo, Cr). Monochromators and channels are utilised to assimilate the undesirable emanation with wavelength $K\alpha$, whereas allowing the best wavelength, $K\beta$ to travel through. The X - beam radiation most typically utilised is that transmitted by copper, whose trademark wavelength for the radiation is akin to 1.5418 Å. The counter is about to seem over a scope of 2θ values at an identical rakish speed. Routinely, a 2θ scope of five to seventy degrees is equal to cowl the foremost valuable piece of the powder style. The checking speed of the counter is often 2θ of 2θ min⁻¹. A finder records and procedures this X - beam sign and changes over the sign to a check rate that is then sustained to a appliance, for instance, a printer or laptop screen. The instance should be ground to fine powder before stacking it within the glass check holder. Check must altogether involve the sq. glass well.

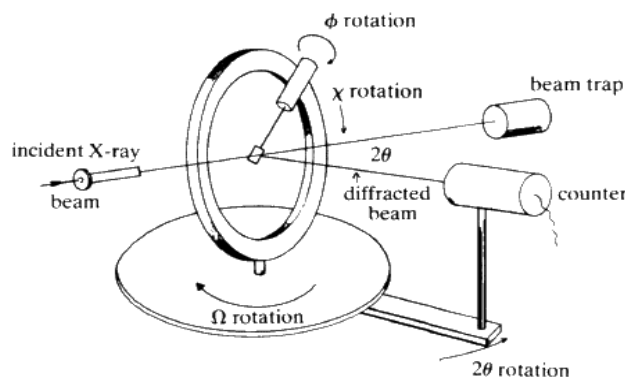


Figure 2.1: Schematics of XRD.

2.1.2 Photoluminescence Spectroscopy (PL)

2.1.2 Photoluminescence Spectrum Analysis (PL)

Photoluminescence spectroscopy could be a contactless, non - ruinous strategy to check the

electronic structure of materials. The force and unearthly substance of the discharged photoluminescence is an instantaneous proportion of various vital material properties, as well as band hole assurance, debasement levels and state location, recombination systems.

Guideline

Light is coordinated onto associate degree example, wherever it's eaten and grants abundance vitality into the fabric in an exceedingly procedure referred to as photograph - excitation. Photograph – excitation makes electrons within a cloth go into cheap energized states. These electrons return to their harmony states, by a radiative procedure (the discharge of light) or by a non - radiative procedure as appeared in figure to a lower place. The quantity of the transmitted lightweight is known with the final commitment of the radiative procedure.

Instrumentation

The visible light instruments contain 3 elementary things: a wellspring of sunshine, associate degree example holder and an indicator. A schematic portrayal of a fluorimeter is appeared. The light source supply delivers light photons over associate degree expansive vitality vary, normally running from two hundred to 900 nm. Photons encroach on the excitation monochromator, that specifically transmits lightweight in an exceedingly tight vary centered concerning the predefined excitation wavelength. The transmitted lightweight goes through versatile cuts that management greatness and goals by any constrictive the scope of transmitted light. The sifted lightweight goes into the instance cell inflicting fluorescent discharge by fluorophors within the example. Transmitted lightweight enters the emanation monochromator, that is located at a ninety ° purpose from the excitation lightweight thanks to dispense with foundation signal and limit clamor due to stray light. Once more, made lightweight is transmitted in an exceedingly restricted vary centered concerning the preset discharge wavelength and exits through customizable cuts, at long last coming into the photomultiplier tube (PMT). The sign is intense and makes a voltage that's relative to the deliberate made force. Commotion within the as well as procedure emerges basically in the PMT. Thusly, phantom goals and sign to clamor is licitly known with the chosen cut widths. Check arrangement method is akin to that of actinic radiation - Visible spectrum analysis. In each the cases, the instance cell (cuvette) should be free from contaminants.

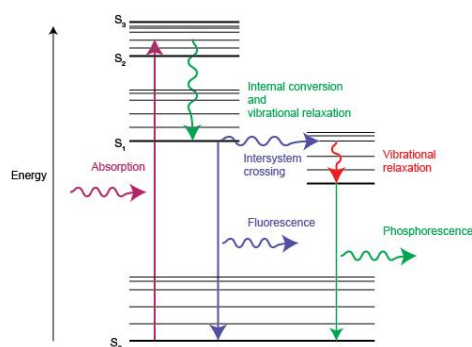


Figure 2.2: Photoluminescence energy bands.

2.1.3. Fourier Transform Infrared (FTIR) Spectroscopy

The infrared spectrum analysis (IR) is one amongst the unimaginable assets for recognizable proof of mixes by coordinative vary of obscure compound with reference range (finger printing), ID of helpful gatherings in obscure substances. The IR district of the magnetic attraction vary is taken into account to hide the range from fifty to twelve, five hundred cm^{-1} roughly. Rule at the purpose once infrared is passed through an example of natural irritate, some frequencies are consumed, whereas totally different frequencies are transmitted while not being assimilated. The advances engaged with the infrared bodily process are connected with the wave changes within the particle. Varied bonds/useful gatherings have distinctive wave frequencies associate degreed consequently the closeness of those bonds in an exceedingly particle will be distinguished by recognizing this trademark return as a bodily process band within the infrared vary. The plot between coefficient against return is named infrared vary. Instrumentation Fourier modification spectrometers have as these days substituted dispersive instruments for many applications due to their prevailing speed and affectability. They need improbably broadened the skills of infrared spectrum analysis and are connected to varied regions that are exceptionally difficult or virtually tough to look at by dispersive instruments. Instead of review each half return consecutively, as in an exceedingly dispersive IR spectroscope, all frequencies are analyzed at the identical time in Fourier modification infrared (FTIR) spectrum analysis. There are 3 elementary spectroscopy components in an exceedingly linear unit framework: radiation supply, measuring instrument and symbol.

2.2 Method of preparation

2.2.1 Synthesis of strontium hexaferrite: Core and Shell



CHAPTER-3: RESULTS AND DISCUSSION

3. RESULTS AND DISCUSSION

3.1. XRD analysis

X-ray diffraction spectra of Strontium hexaferrite, CdS and Strontium hexaferrite@CdS core-shell structure is shown in fig. 3.1-3.3. XRD pattern for strontium hexaferrite shows peaks at (110), (107), (114), (203) and (205) hkl planes which indicates magneto-plumbite structure for Strontium hexaferrite. In CdS spectra the prominent peaks at 260, 440 and 510 corresponds to (002), (100) and (112) represents the wurtzite structure of CdS. The crystallite size (D) of QDs has been calculated using Scherer's formula.

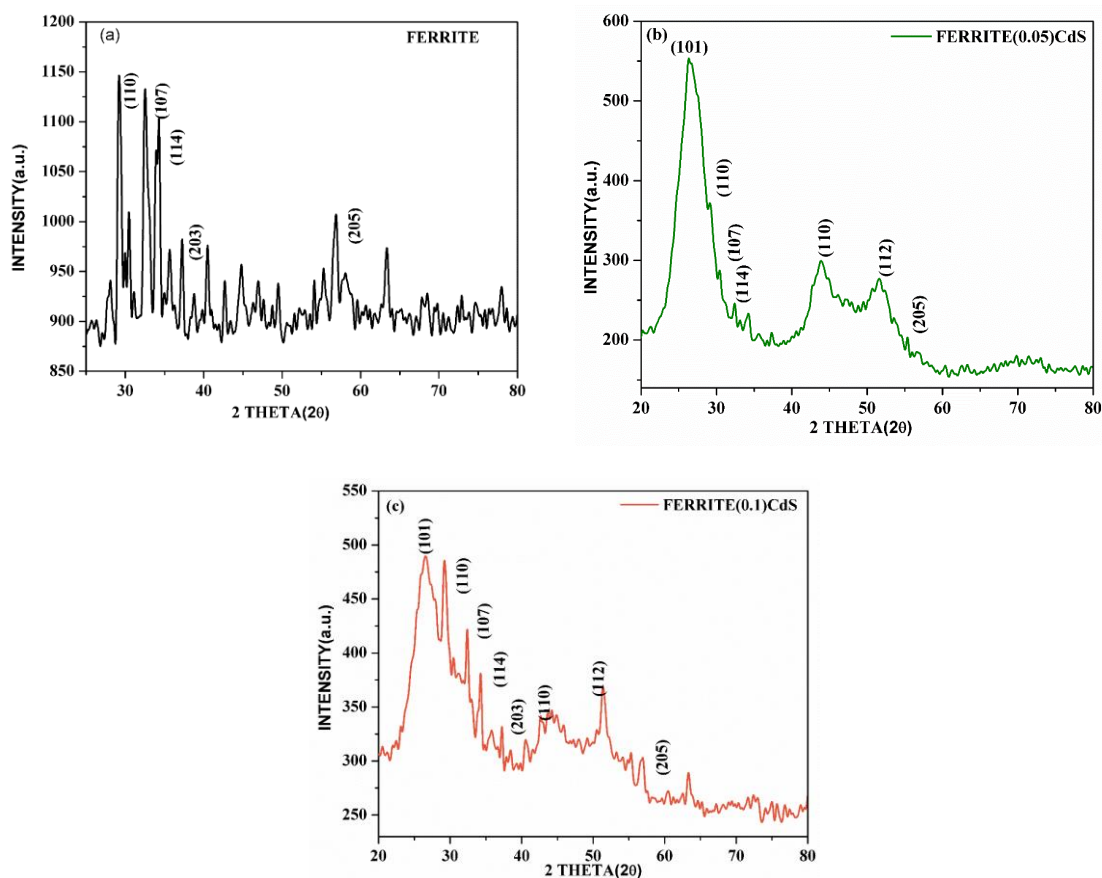
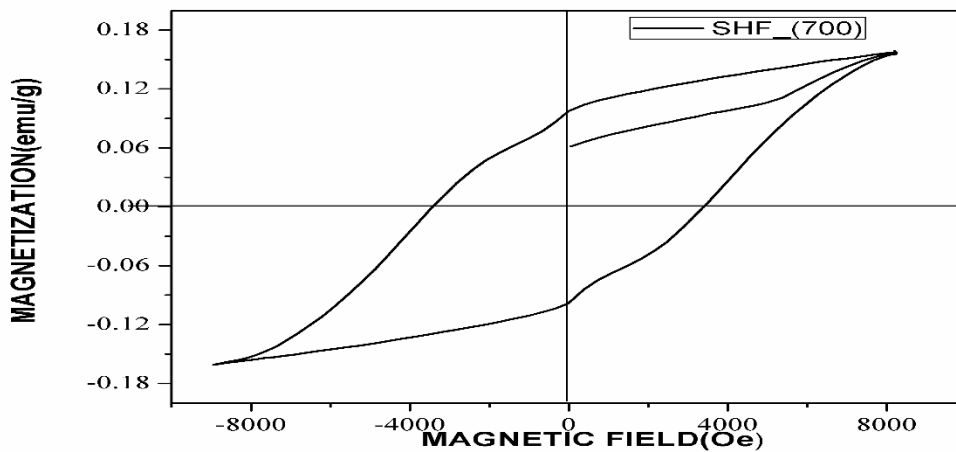
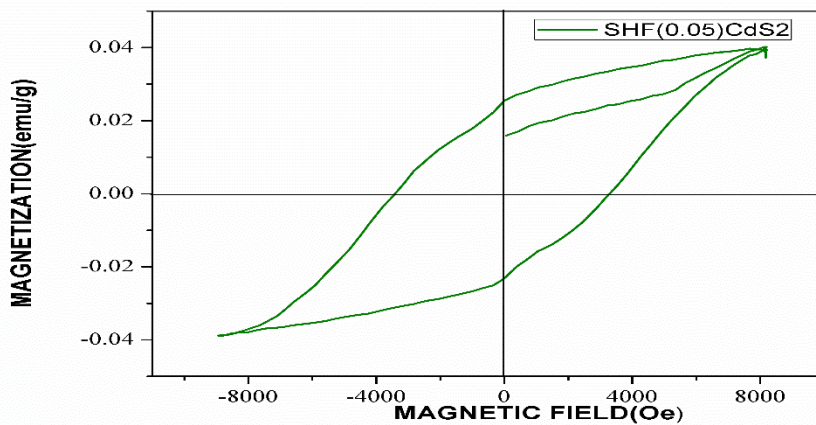
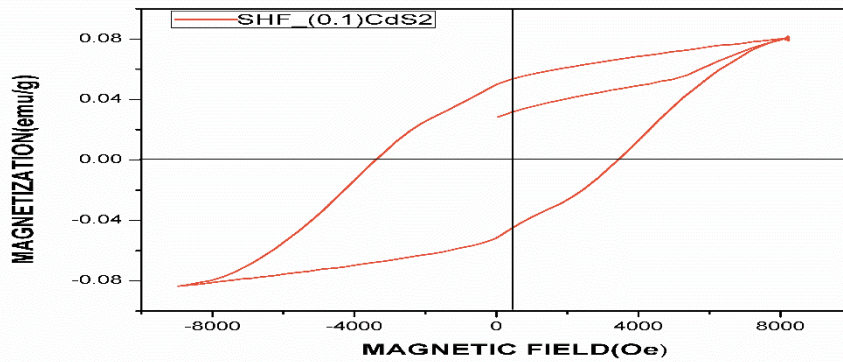


Figure 3.1: XRD spectra of Strontium Hexaferrite and their core@shell nanostructures with different ferrite loading

The average crystallite size of CdS QDs was 1.8nm which was obtained from prominent peak at 2 thetas 30.11 (002). Calculated particle size of Strontium hexaferrite was 21 nm. Calculation of particle size for core shell structure was not possible by XRD because these structures contain separate peaks of both Strontium hexaferrite and CdS QDs.

VSM Results :

In case of pure ferrite saturation magnetization is around 0.18 emu/g, while with the core shell formation saturation magnetisation is decaying, this is due to the presence of non-magnetic CdS shell over pure ferrite, hence it is also a proof of core shell formation.



3.2. Photoluminescence study

The photoluminescence spectra of CdS quantum dots shell and Strontium hexaferrite/CdS core/shell nanoparticles are recorded at an excitation wavelength of 290 nm and have been shown in fig. 3.4 (a-c). Core/shell nanoparticles with ferrite loading (0.1 gm) shows three peaks at 350 nm, 458 nm and 490 nm peak present at near about 350 nm was very much intense as compare to other two peaks. This peak is found to be of strontium oxide and may be present due to high tendency of Sr present in strontium hexaferrite to combine with oxygen present in atmosphere.

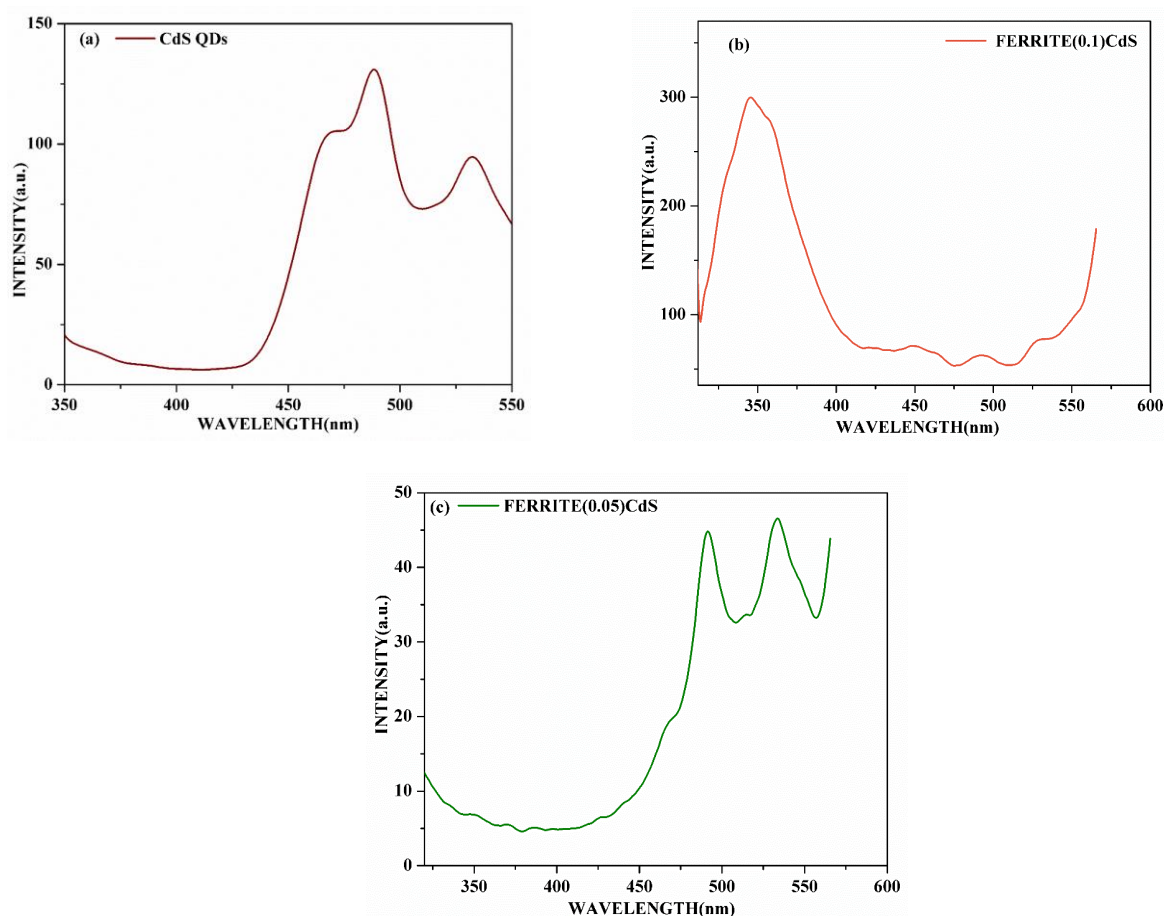


Figure 3.4: PL spectra for (a) CdS quantum dots; (b) Core/shell with 0.1 gm ferrite loading and (c) Core/shell with 0.05 gm ferrite loading

Whereas in case of core/shell where ferrite concentration was 0.05 gm shows two peaks at 490 nm and 532 nm. This position is much similar to the peak position of pure CdS quantum dots shell. The only difference is in the intensity which may be due to the effect of magnetic core. Also, the presence of three peaks in this case of 0.1 gm ferrite loading core\shell structure concludes poor control on size distribution of CdS. While in case of ferrite

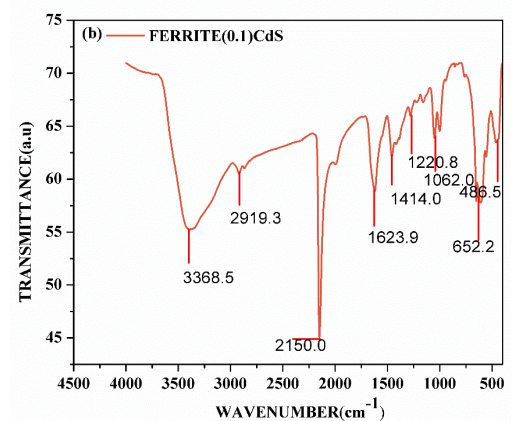
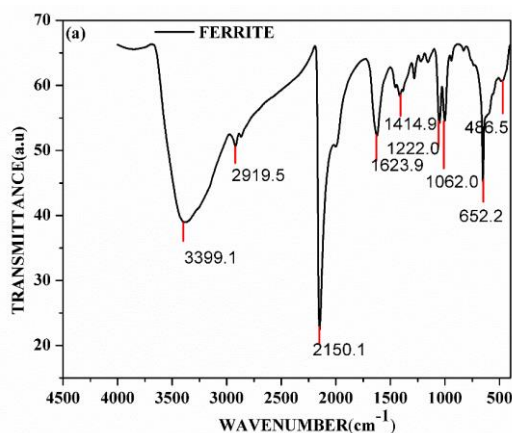
concentration (0.05gm) PL spectra show CdS peaks at 490nm and 532nm which shows as we are decreasing the loading of ferrite nanoparticles, we can attain better size distribution and the extra peak of strontium oxide is also eliminated. Table 3.1 presents the compiled data from PL studies.

Table 3.1 Compiled data from PL studies.

S. No	Sample name	Peak positions (nm)	Intensity
1.	CdS	460, 480, 535	196, 236, 182
2.	Ferrite (0.1gm) CdS	350, 458, 490	289, 50, 41
3.	Ferrite (0.05gm) CdS	490, 532	52, 50

3.3. FT-IR analysis

The FTIR-spectra of Strontium hexaferrite, CdS and Strontium hexaferrite /CdS core/shell structures are shown in fig 3.5 (a-c) for Strontium hexaferrite the characteristic bands have appeared in the range of 3200- 3270 cm^{-1} and 1623 cm^{-1} . These bands are assigned to be hydroxyl and carboxyl group of citric acid respectively. The absorption peak at 1222.0 cm^{-1} corresponds to C-O stretching vibration of C-O-H band. Frequency bands near 1460.37 cm^{-1} , 1383.59 cm^{-1} and 858.82 cm^{-1} are attributed to nitrate ions. The observed absorption bands in the range 400- 800 cm^{-1} are due to iron oxide.



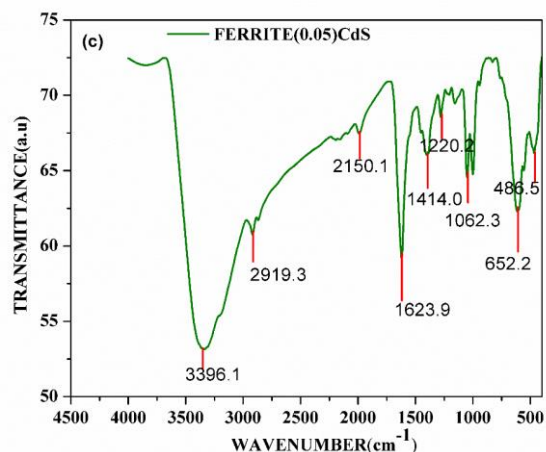


Figure 3.5. FT-IR spectra of Strontium hexaferrite, and Strontium hexaferrite /CdS core/shell structures

The absorption band at 2919.4 cm⁻¹ arise from Fermi resonance between stretching vibration of O-H band and combination of frequency of stretching vibration of C-O and bending vibration of C-O-H band. In case of core shell nanostructures, the broad peak at 2919, 1383 cm⁻¹ and the weak peak at 1220 cm⁻¹ were assigned to C-H characteristic vibrations in the CdS sample as marked shown in the spectra. The sharp peak at 3395 cm⁻¹ corresponds to (O-H) alcohols and 1119 cm⁻¹ show (C-N) amines along with two small peaks at 1626 cm⁻¹ for (N-H) amines and 1401cm for O-H means carboxylic acid in CdS samples.

3.4. IC₅₀

It is the measure of potency of a substance or a drug inhibiting specific biological function or biochemical function. It's a 50% inhibition of bacterial growth. The IC₅₀ value helps us determine the toxicity of the substance. Mcfarland standard used was 0.5 for E.coli DH5α.

Tables for IC₅₀ values given below

For Ferrite 0.1, CdS(2) (Compound A)

Sample Conc. (mg/ml)	OD1	OD2	OD _{avg}
Blank	0.163	0.178	0.171
62.5	0.162	0.199	0.181
125	0.167	0.166	0.167
250	0.168	0.187	0.178
500	0.167	0.186	0.177

For Ferrite (0.05), CdS(2) (Compound B)

Sample Conc. (mg/ml)	OD1	OD2	ODavg
Blank	0.235	0.198	0.217
62.5	0.203	0.188	0.196
125	0.171	0.152	0.162
250	0.151	0.161	0.156
500	0.132	0.131	0.132

IC₅₀ values show that compound A was not toxic to microbial concentration upto 500 mg/ml, where as compound B is able to kill 50% of E.Coli (DH5 α) cells. This compound has advantage that in low concentration it will not be toxic to microbial system. The compounds were soluble as well. When the concentration is more that 500 mg/ml the compound starts being toxic. Since this compound was not toxic to microbial concentration hence it finds its application in Biological Cell-Sorting, Cell-Manipulation and Microbial Imaging.

CHAPTER – 4: CONCLUSION

4. Conclusion

It will be summarized from the study conducted that quantum dots are of terribly little size which might be synthesized mistreatment binary compound root. We have a tendency to additionally learned that there are 2 techniques for the synthesis of nanoparticles particularly high down and bottom up techniques. Ferrites are magnetic ceramics containing iron chemical compound as a significant constituent in it. Our work revolves round the multifunctional NPs that we've synthesized and later are fashioned because the core shell structure. We've taken the inner core that could be a primary solid solution and also the shell we have opted for is a semiconductor. The core shell was with success created and characterized. The core shell was characterized by XRD (X-Ray optical phenomenon spectroscopy), Photoluminescence (PL) analysis and Fourier rework spectroscopy (FTIR). Technique used for the synthesis was the sol - gel technique. The average crystal size of CdS QDs was one.8nm that was obtained from outstanding peak at a pair of thetas thirty.11 (002). Calculation of particle size for core shell structure wasn't doable by XRD as a result of these structures contain separate peaks of each metallic element hexaferrite and CdS QDs.

Poor management on size distribution of CdS is discovered within the PL spectrum analysis incontestable by the presence of 3 peaks. Just in case of core/shell wherever primary solid solution concentration was 0.05 grams shows 2 peaks at 490 nm and 532 nm. This position is far the same as the height position of pure CdS quantum dots shell. The sole distinction is within the intensity, which can result to the result of core. Analyzing the FTIR Results for metallic element hexaferrite the characteristic bands have appeared within the vary of 3200- 3270 cm^{-1} and 1623 cm^{-1} . These bands are appointed to be hydroxyl radical and radical of acid severally. Frequency bands close to 1460.37 cm^{-1} , 1383.59 cm^{-1} and 858.82 cm^{-1} are attributed to nitrate ions. The discovered absorption bands within the vary 400- 800 cm^{-1} are because of iron chemical compound. . The sharp peak at 3395 cm^{-1} corresponds to (O–H) alcohols and 1119 cm^{-1} show (C–N) amines together with 2 little peaks at 1626 cm^{-1} for (N–H) amines and 1401 cm^{-1} for O–H means that acid in CdS samples.

The IC_{50} results tell us that Compound A (ferrite (0.1) CdS₂) was not toxic to microbial system where as compound B (ferrite (0.05) CdS₂) was able to kill 50% of the E.Coli cells at the 500 mg/ml concentration.

5. References

- [1] Akbarzadeh, A., Mikaeili, H., Zarghami, N., Mohammad, R., Barkhordari, A. and Davaran, S., 2012. Preparation and in vitro evaluation of doxorubicin-loaded Fe₃O₄ magnetic nanoparticles modified with biocompatible copolymers. *International journal of nanomedicine*, 7, p.511.
- [2] Carneiro-da-Cunha, M.G., Cerqueira, M.A., Souza, B.W., Carvalho, S., Quintas, M.A., Teixeira, J.A. and Vicente, A.A., 2010. Physical and thermal properties of a chitosan/alginate nanolayered PET film. *Carbohydrate Polymers*, 82(1), pp.153-159.
- [3] Chen, O., Riedemann, L., Etoc, F., Herrmann, H., Coppey, M., Barch, M., Farrar, C.T., Zhao, J., Bruns, O.T., Wei, H. and Guo, P., 2014. Magneto-fluorescent core-shell supernanoparticles. *Nature communications*, 5, p.5093
- [4] Davaran, S., Alimirzalu, S., Nejati-Koshki, K., Nasrabadi, H.T., Akbarzadeh, A., Khandaghi, A.A., Abbasian, M. and Alimohammadi, S., 2014. Physicochemical characteristics of Fe. *Asian Pac J Cancer Prev*, 15, pp.49-54.
- [5] Faucon, A., Hémez, J., Fresnais, J. and Ishow, E., Magnetofluorescent Nanoparticles: a Reverse Approach for High-Loaded Active Materials.
- [6] Fielding, L.A., Mykhaylyk, O.O., Armes, S.P., Fowler, P.W., Mittal, V. and Fitzpatrick, S., 2012. Correcting for a density distribution: particle size analysis of core-shell nanocomposite particles using disk centrifuge photosedimentometry. *Langmuir*, 28(5), pp.2536-2544.
- [7] Fraser, B., Tobin, K. and McRobbie, C.J. eds., 2011. *Second international handbook of science education* (Vol. 24). Springer Science & Business Media
- [8] Jenkins, R., 2000. X-ray techniques: overview. *Encyclopedia of analytical chemistry*, pp.13269-13288.

- [9] Kirupakar, B.R., Vishwanath, B.A. and Sree, M.P., 2016. Vibrating Sample Magnetometer and Its Application In Characterisation Of Magnetic Property Of The Anti Cancer Drug Magnetic Microspheres. *International Journal of Pharmaceutics and Drug Analysis*, 4, pp.227-233.
- [10] Kharade, R.R., Mane, S.R., Mane, R.M., Patil, P.S. and Bhosale, P.N., 2010. Synthesis and characterization of chemically grown electrochromic tungsten oxide. *Journal of sol-gel science and technology*, 56(2), pp.177-183.
- [11] Louis, K.S. and Siegel, A.C., 2011. Cell viability analysis using trypan blue: manual and automated methods. In *Mammalian cell viability* (pp. 7-12). Humana Press.
- [12] Peisien, H.S. and Rooksry, H.P., 1955. *X-Ray Diffraction By Polycrystalline Materials*. The Institute Of Physics; London.
- [13] Serrano García, R., Stafford, S. and Gun'ko, Y., 2018. recent progress in synthesis and functionalization of multimodal fluorescent-magnetic nanoparticles for biological applications. *Applied Sciences*, 8(2), p.172.
- [14] Thermo, N., 2001. Introduction to Fourier transform infrared spectrometry. *Thermo Nicolet Corporation: Madison-USA*.
- [15] Turcu, R., Craciunescu, I., Garamus, V.M., Janko, C., Lyer, S., Tietze, R., Alexiou, C. and Vekas, L., 2015. Magnetic microgels for drug targeting applications: Physical–chemical properties and cytotoxicity evaluation. *Journal of magnetism and magnetic materials*, 380, pp.307-314.
- [16] Vankayalu Devendiran Sundar, Magharla Dasaratha Dhanaraju, Nandhakumar Sathyamoorthy. Fabrication and characterization of etoposide loaded magnetic polymeric microparticles. *International Journal of Drug Delivery* 6 (2014) 24-35.
- [17] Venkataraman, M., 2005. The effect of colloidal stability on the heat transfer characteristics of nanosilica dispersed fluids.

[18] WuShiZuo, PengJinHua; LiFengSheng. Preparation and Characterization of Fluorescent Magnetic Target Drug Delivery System. PhD thesis. Nanjing University of Technology and Engineering. 2012. <http://www.dissertationtopic.net/doc/1703534> (accessed on 06 March 2016).

[19] Yang, X., Chen, L., Han, B., Yang, X. and Duan, H., 2010. Preparation of magnetite and tumor dual-targeting hollow polymer microspheres with pH-sensitivity for anticancer drug-carriers. *Polymer*, 51(12), pp.2533-2539.

[20] Zairov, R., Mustafina, A., Shamsutdinova, N., Nizameev, I., Moreira, B., Sudakova, S., Podyachev, S., Fattakhova, A., Safina, G., Lundstrom, I. and Gubaidullin, A., 2017. High performance magneto-fluorescent nanoparticles assembled from terbium and gadolinium 1, 3-diketones. *Scientific reports*, 7, p.40486.

[21] Zhang, L.L., Li, P., Li, Y.M. and Wang, A.Q., 2012. Preparation and characterization of magnetic alginate-chitosan hydrogel beads loaded with matrine. *Drug development and industrial pharmacy*, 38(7), pp.872-882.

[22] Zhou, S., Sun, J., Sun, L., Dai, Y., Liu, L., Li, X., Wang, J., Weng, J., Jia, W. and Zhang, Z., 2008. Preparation and characterization of interferon-loaded magnetic biodegradable microspheres. *Journal of Biomedical Materials Research Part B: Applied Biomaterials: An Official Journal of The Society for Biomaterials, The Japanese Society for Biomaterials, and The Australian Society for Biomaterials and the Korean Society for Biomaterials*, 87(1), pp.189-196.