Nanotechnology and its Application in Cancer Treatment

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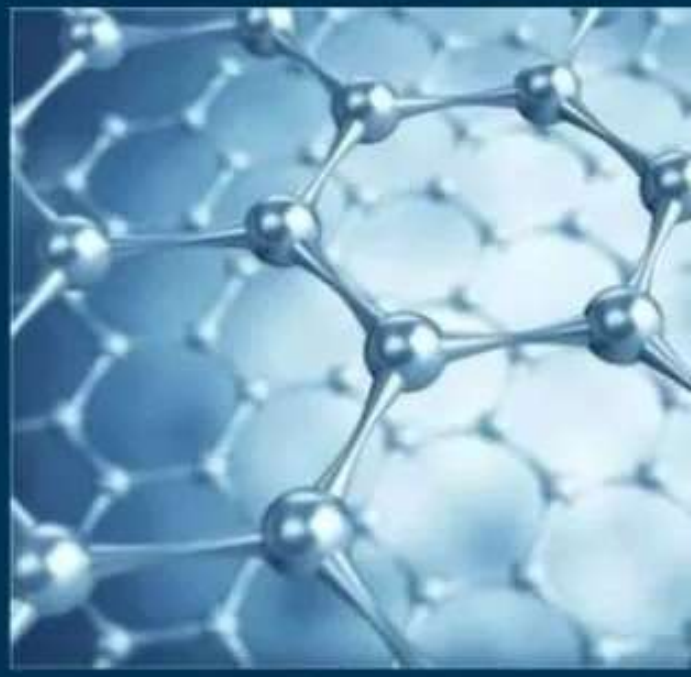
Nanotechnology

- The art and science of manipulating matter at the nanoscale.
- Range = **1-100 nm**

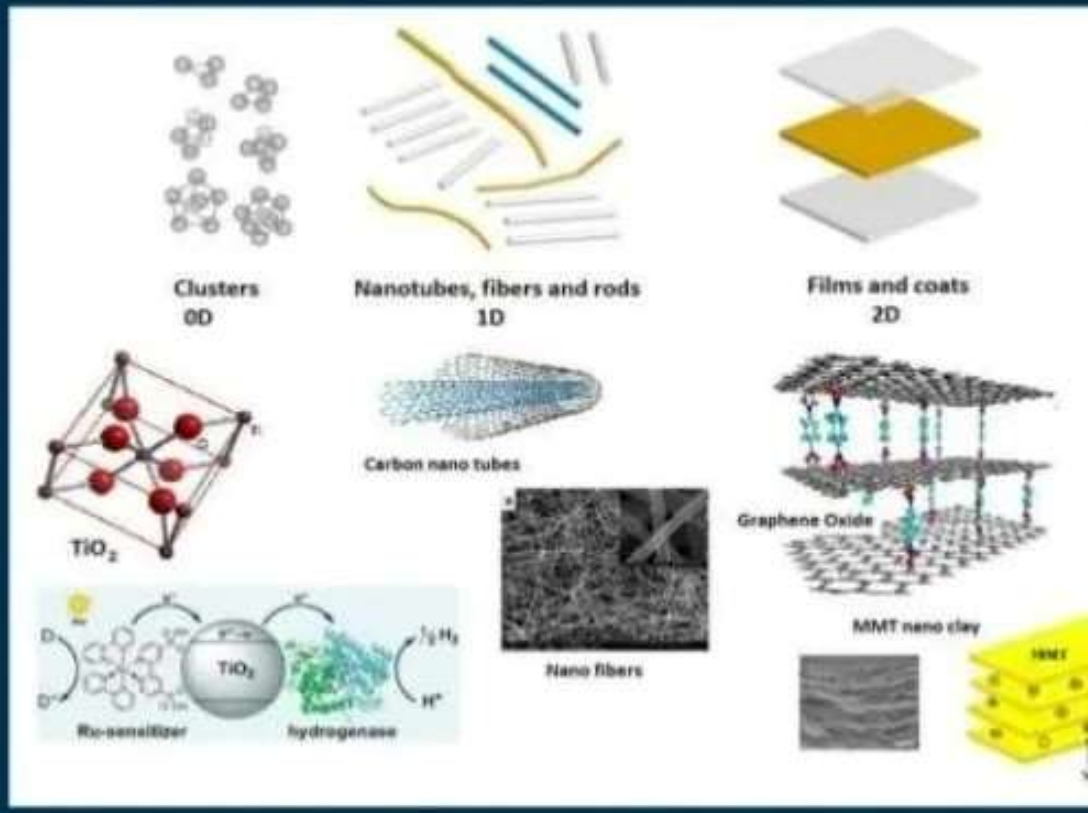


Nanomaterials

- These are an arrangement of molecules and atoms that when combined c stable building blocks that can be made into larger, more complex materia structures.
- In nanomaterials the surface area to volume ratio increases with decrease characteristic dimensions of the material and vice versa.
- Nanomaterials have **high reactivity** .

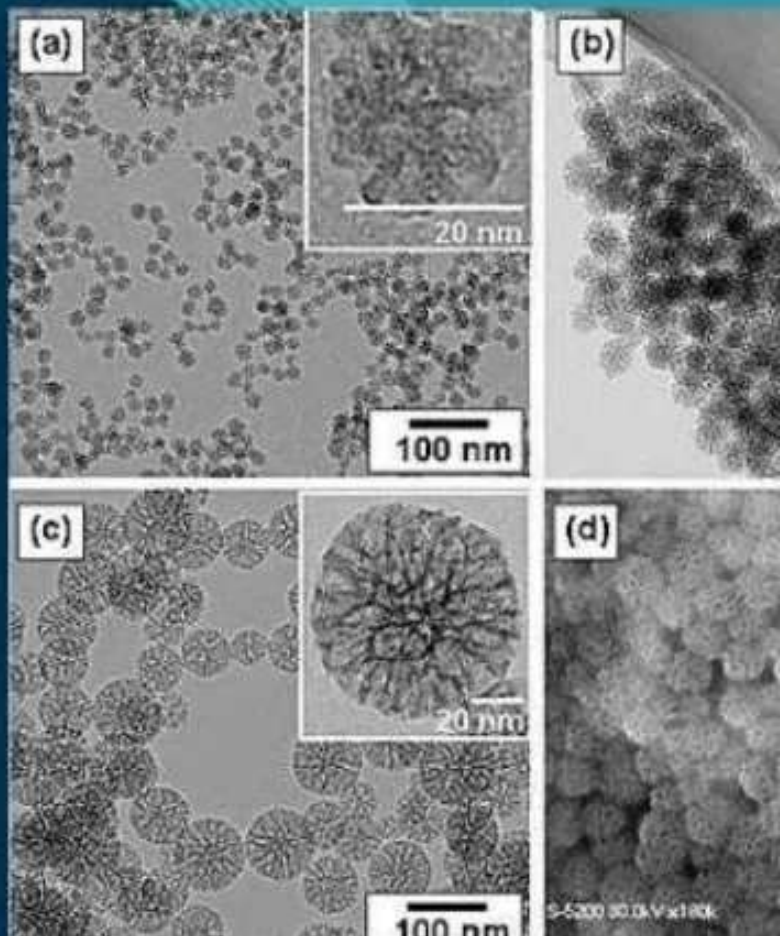
Nanostructures

- A nanostructure is an object that have at least **one dimension** in the range of 1-100 nm.
- There are 4 dimensions in nanostructures: (0D, 1D, 2D, 3D).



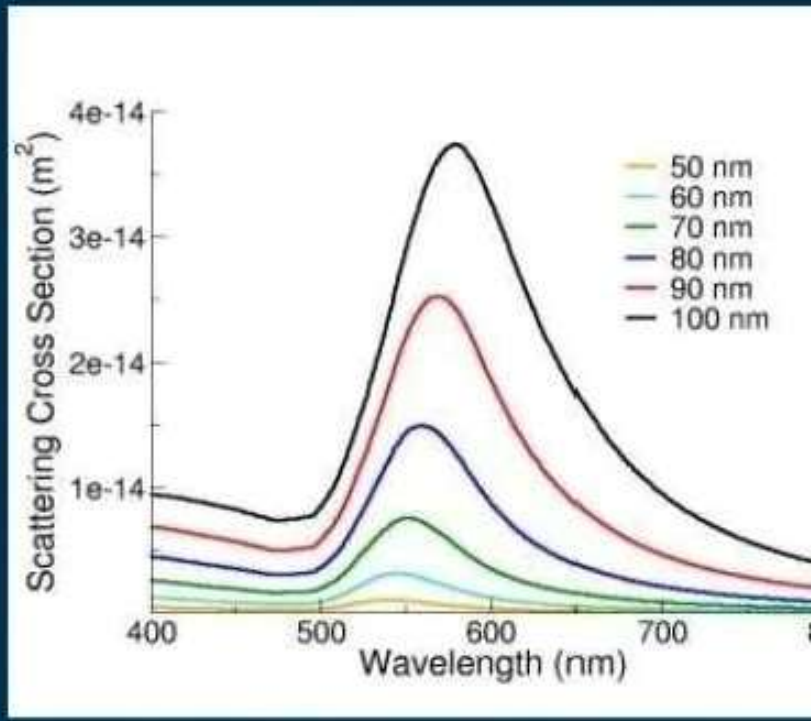
Nanoparticles

- Radius in the range of 1-100 nm
- Large surface area
- Nano/quantum physical phenomenon present
- Unexpected optical properties



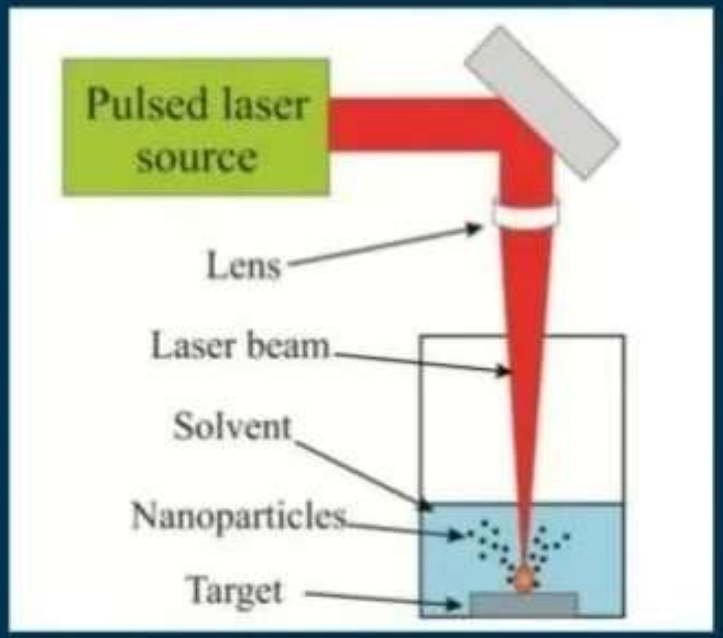
Unexpected Optical Properties of Nanoparticles

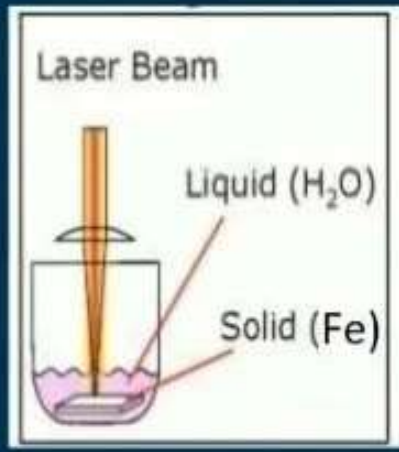
- The color of NPs changes at nanometer scale.
- They are small enough to confine their electrons and to produce quantum effects.
- Spherical **Iron** NPs with diameter of 25 nm look green
- **Iron** NPs with 100 nm in diameter look orange

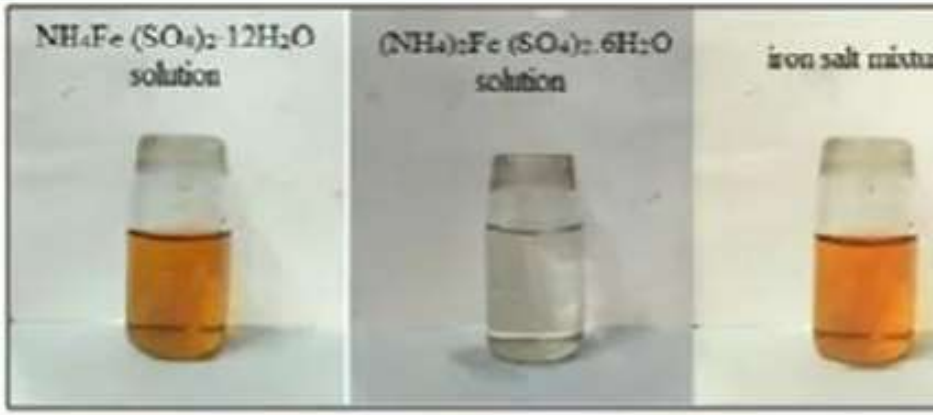


Synthesis of Nanoparticles

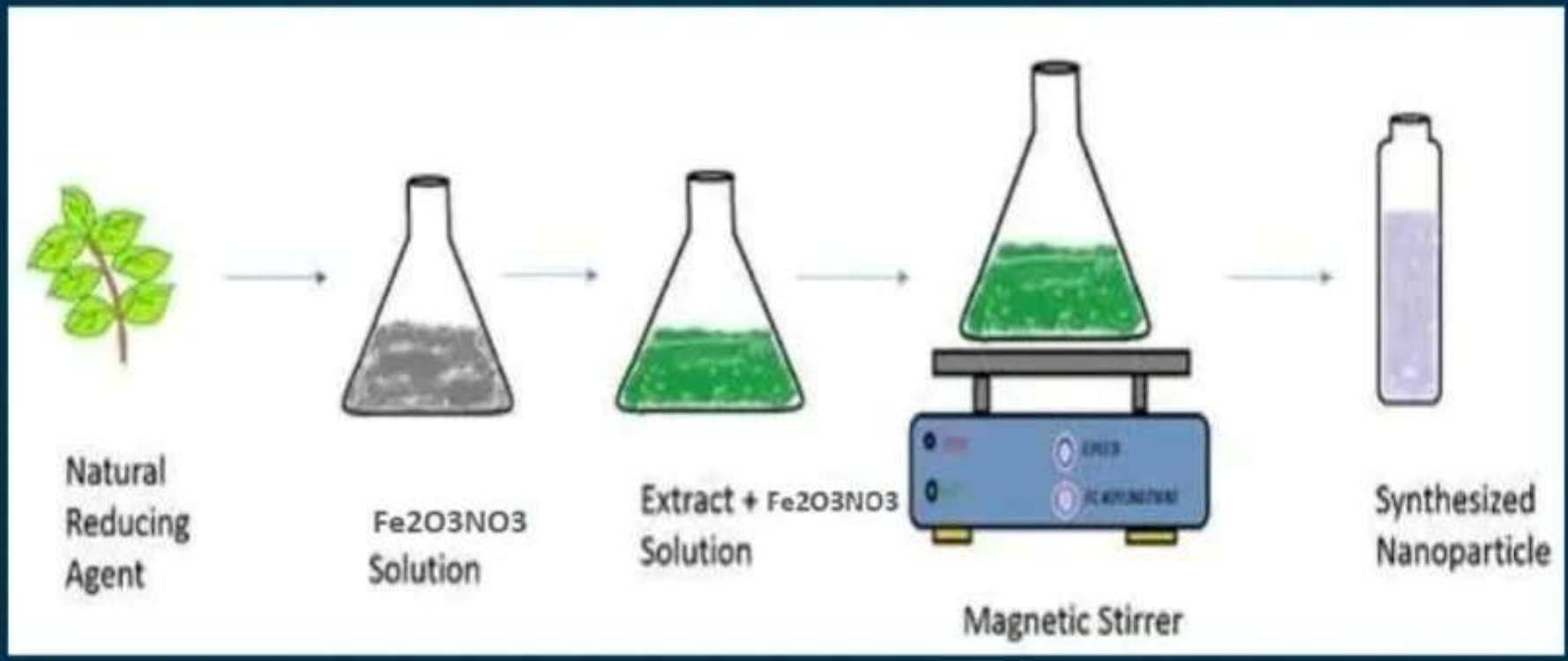
Laser Ablation Method

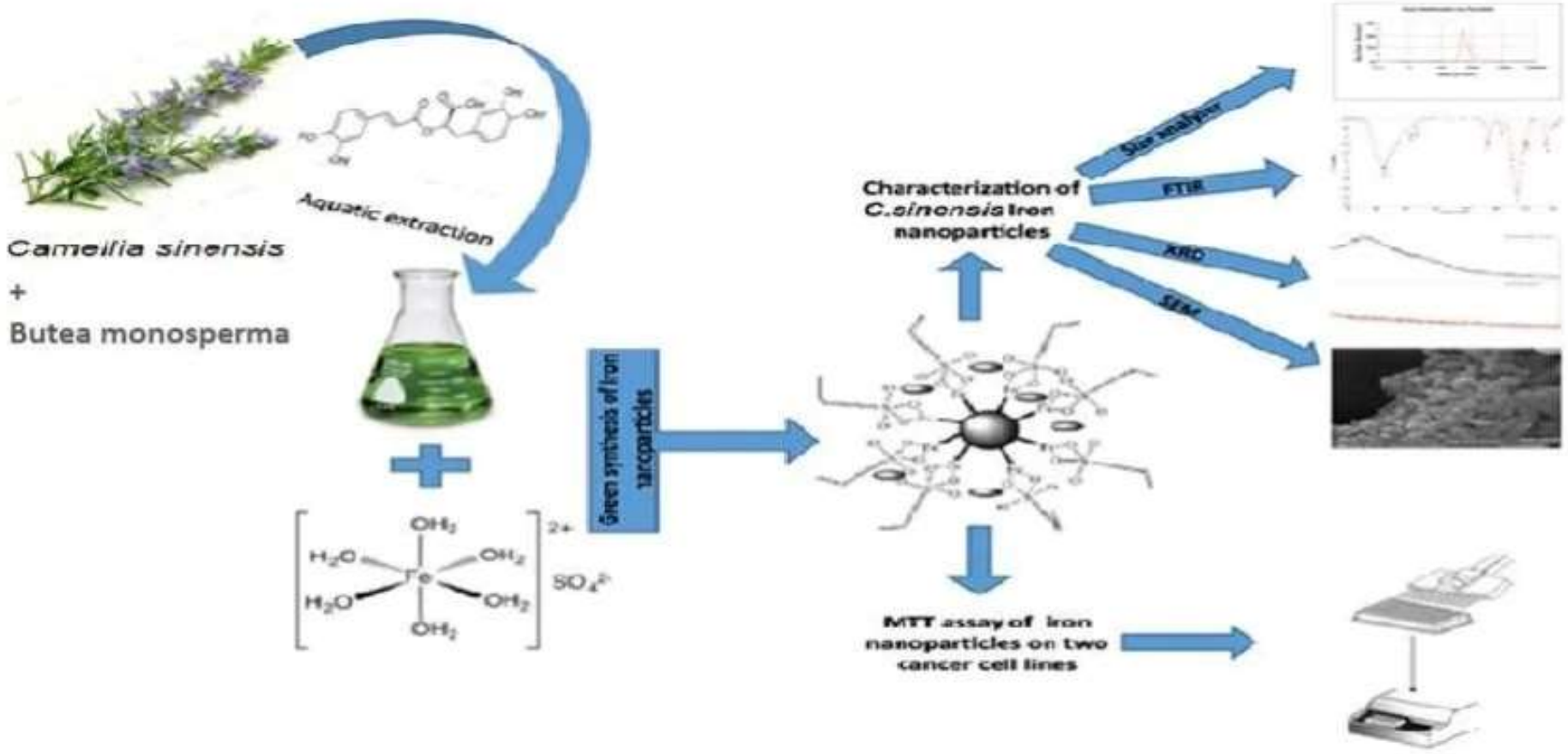




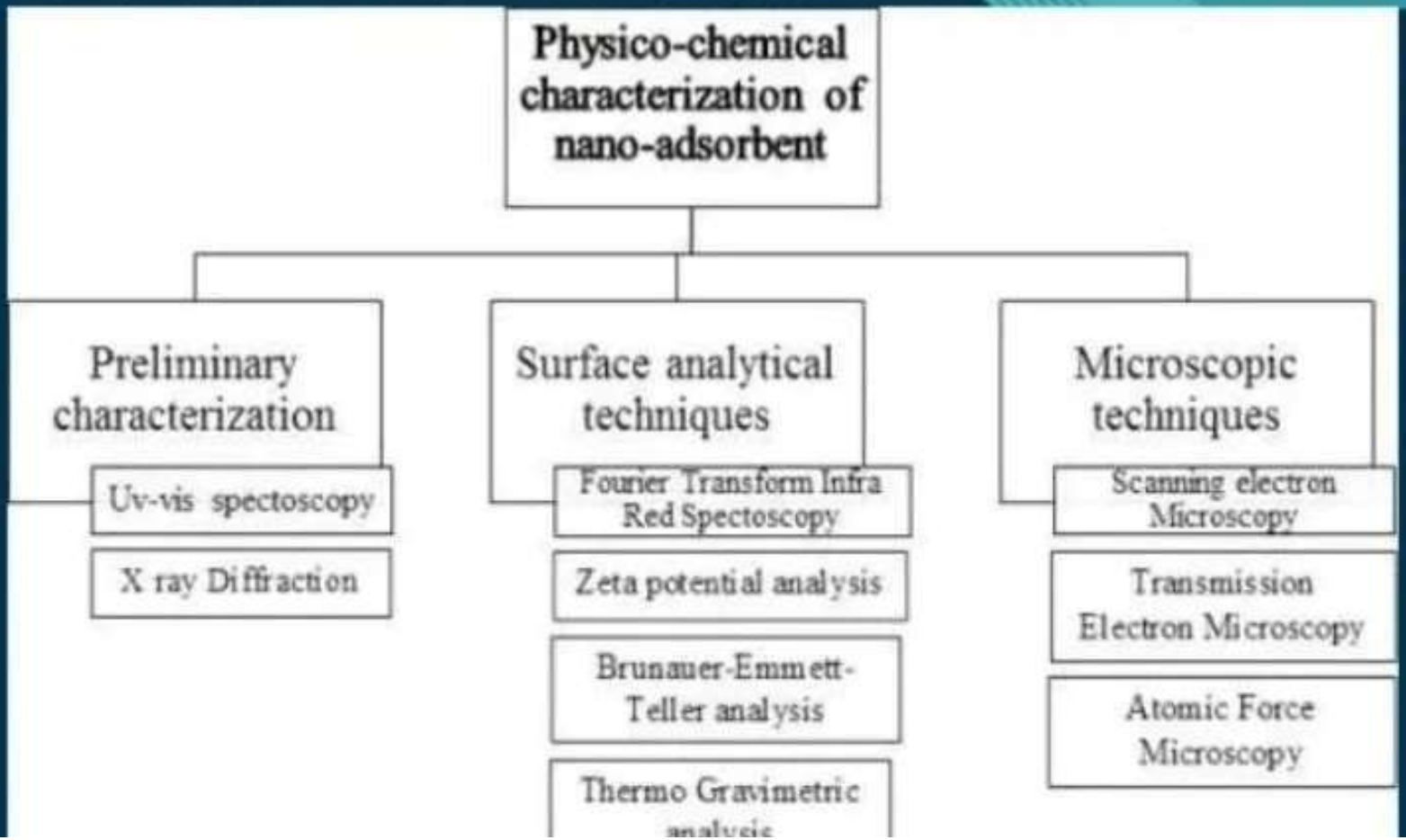


Green Synthesis of Nanoparticles

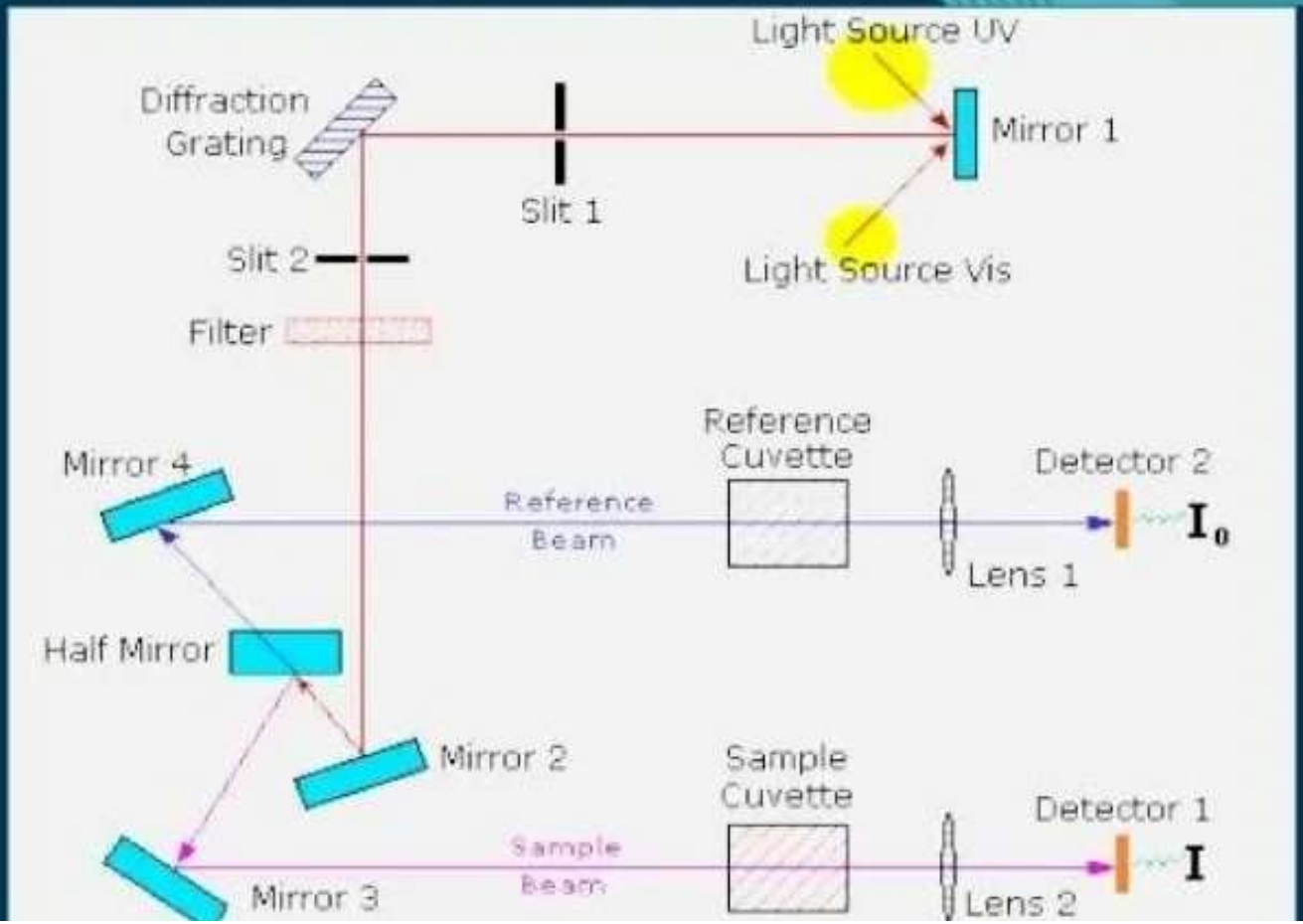



Camellia sinensis
+
Butea monosperma
Aquatic extraction
Green synthesis of iron nanoparticles
Characterization of C.sinensis Iron nanoparticles
Size analyser
FTIR
XRD
SEM
MTT assay of iron nanoparticles on two cancer cell lines

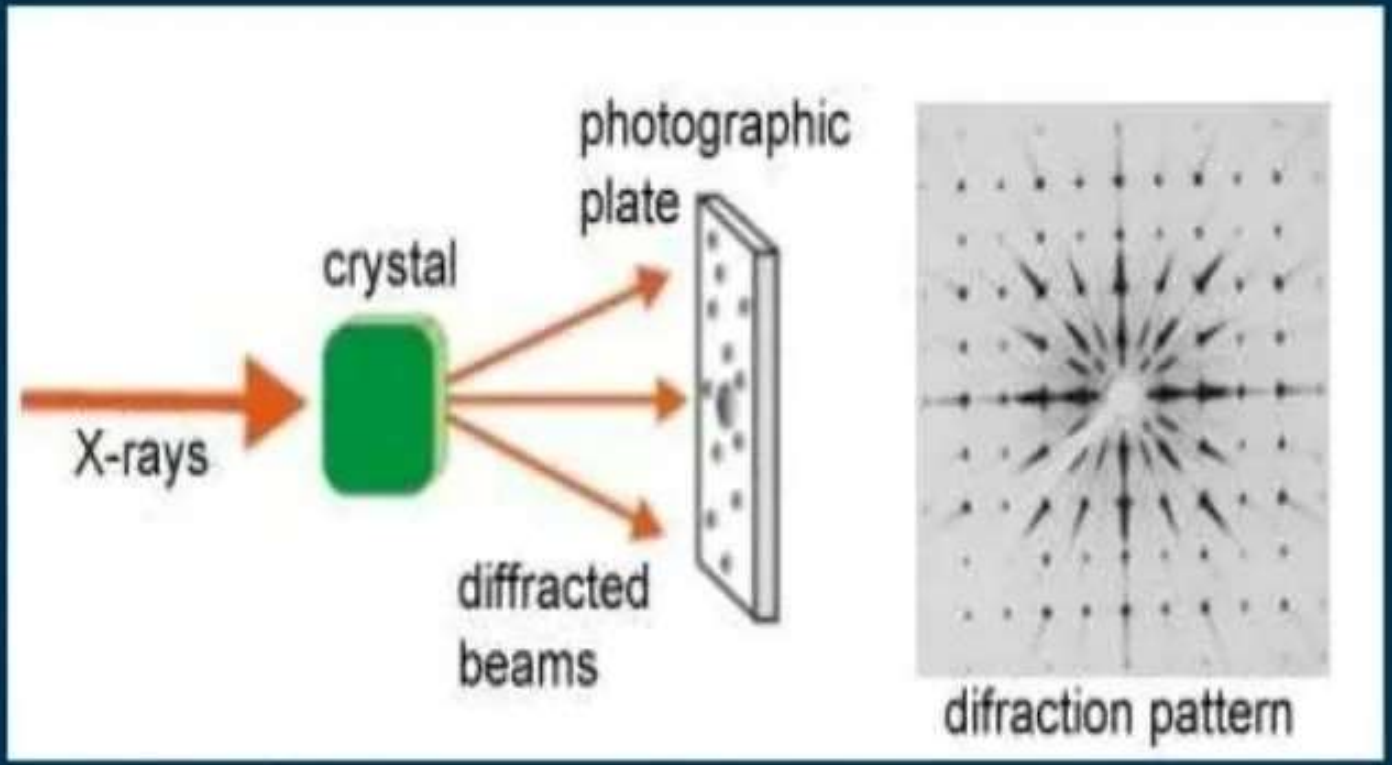
Characterization of Nanoparticles



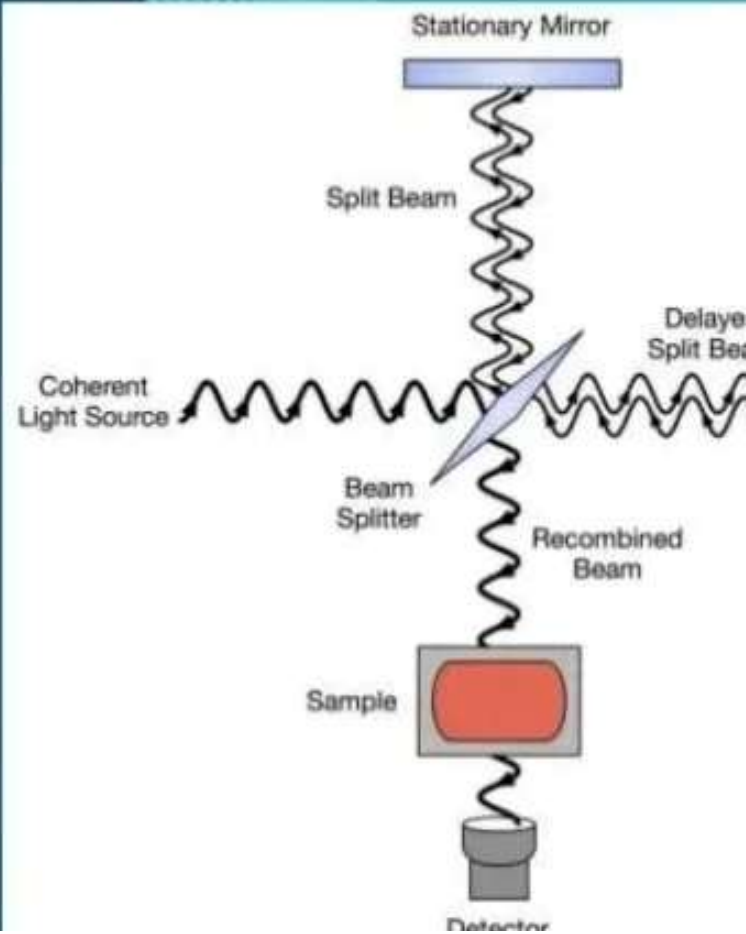
UV-Vis Spectroscopy



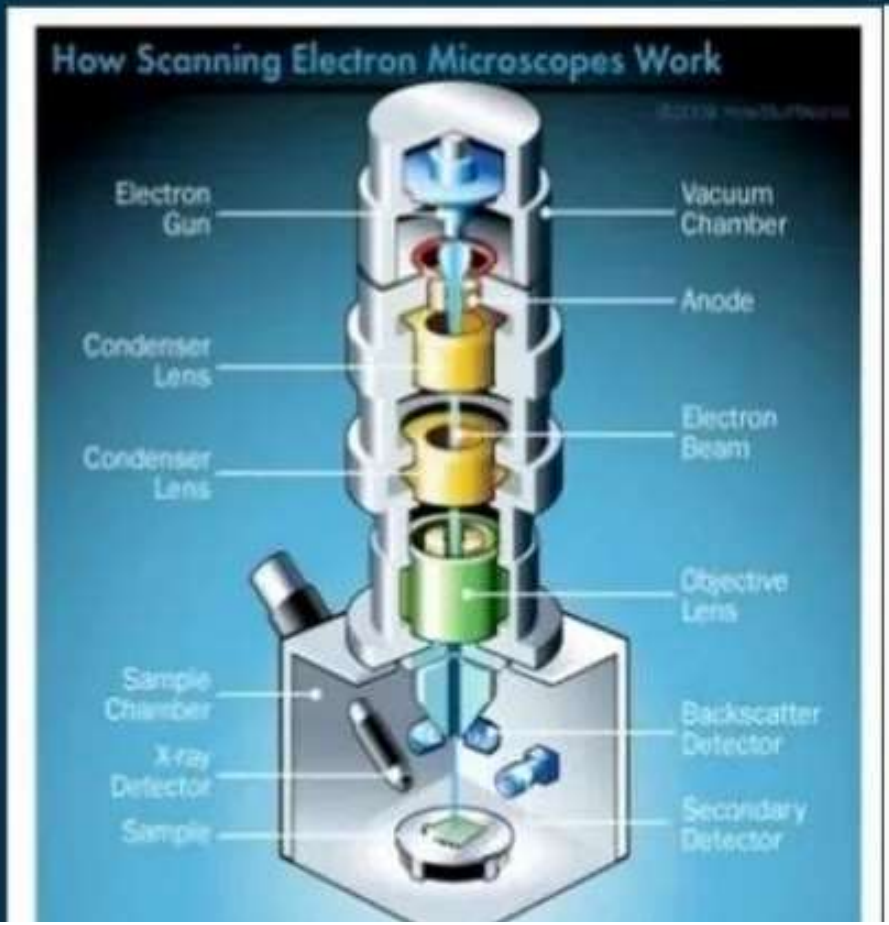
X-Ray Diffraction (XRD)

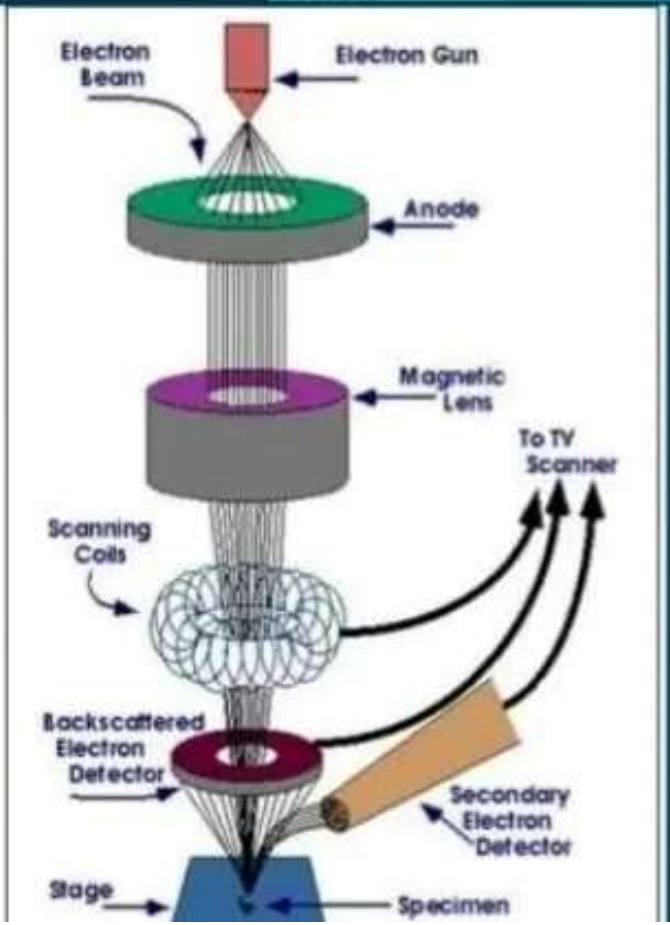


Fourier transform infrared spectrometer (FT-IR)



Scanning Electron Microscope (SEM)





Nanotechnology in Cancer Treatment

- Nanotechnology can be used for

a) better cancer diagnosis

b) more efficient drug delivery to tumour cells

c) molecular targeted cancer therapy

Role of IRON NPs in Cancer Treatment

- **Iron** is an interesting element for tumour uptake because it plays an important role in cellular metabolism.
- **Iron Oxide nanoparticles due to their superparamagnatic properties have a great impact on dignosis and Cancer Therapy.**
- **Iron** -containing antioxidant systems showed decrease the levels of harmful ROS.
- DATS can be bioreduced in cancer cells and thereby influencing the transmission of signals regulating cell proliferation.

Breast Cancer Cell Lines Used in Research

- Breast carcinoma cell line (MCF-7)
- Breast carcinoma cell line (MDA-MB-231)

❖ These cell lines were obtained from ATCC.

Iron Nanoparticles Preparation

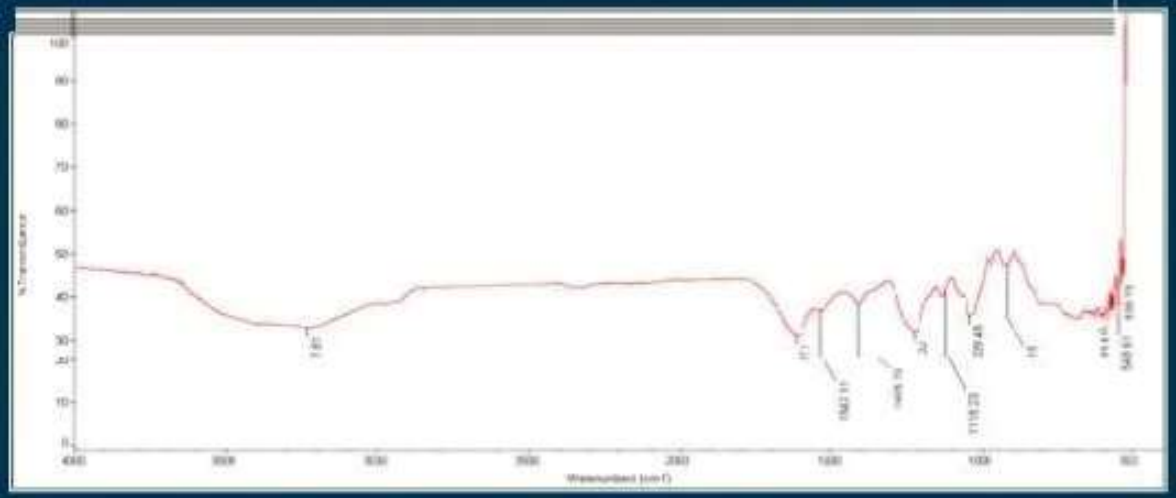
- In a typical experiment, for biosynthesis of Hematite (α-Fe2O3), 60 mL of aqueous plant extract *B. monosperma* & *C. sinensis* 10% (10 mL extract and 90 mL deionized water) was mixed with 40 mL Fe2O3NO3 solution (0.01 M) in 250 mL Erlenmeyer flask.
- The flask was incubated for 24 h at 27°C at 120 rpm
- A small aliquot of the solutions was used for the ultraviolet-visible (UV-Vis) spectroscopy.
- After 24 h incubation time, the reaction mixture was centrifuged at 14,000 rpm (Vision Scientific co.) for 15 min and the pellet was resuspended in a small amount of deionized water and then a small amount of suspension was sprayed on a glass slide

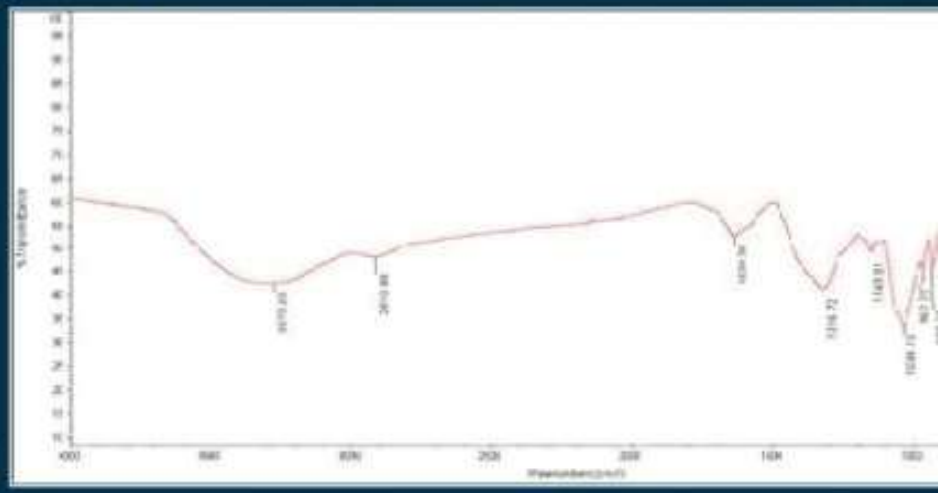
MTT Assay

- Colorimetric Assay
- Used to find out the viability of the cell.
- Tetrazolium dye
- NADPH dependent oxidoreductase produce by mitochondria when the cell is viable. This enzyme converts terazolium dye into a purple colored compound.
- The effect of FeNPs on growth of cancer cells (MCF-7, MDA-MB-231) was assed by MTT Assay.

FT-IR Characterization of Iron Nanoparticles

- The synthesized nanoparticles were characterized by FT-IR for the evaluation of their composition and purity.



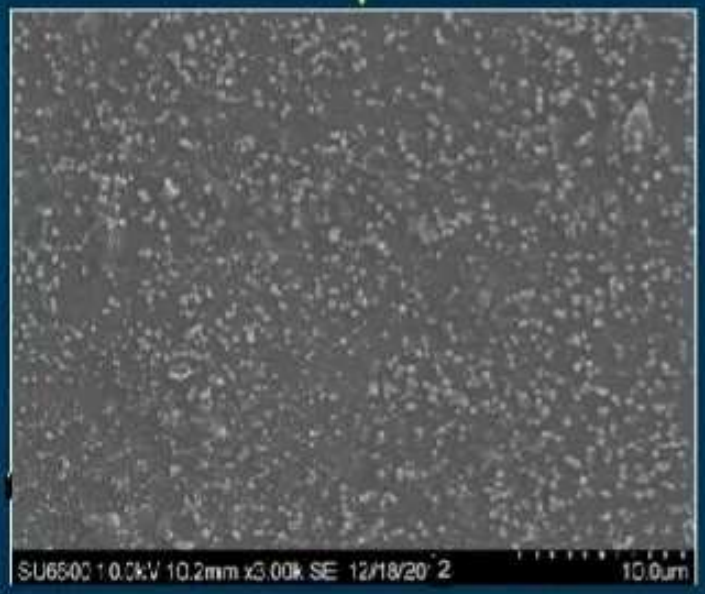


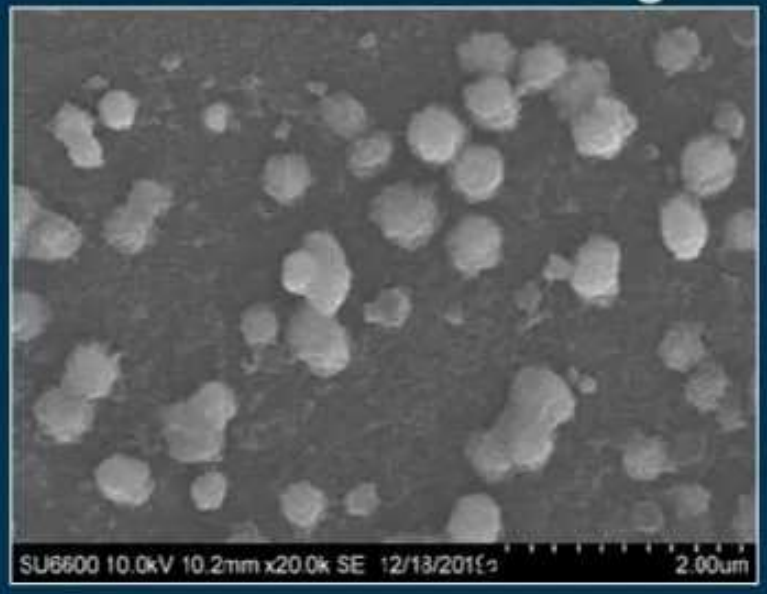
500 cm^{-1} and 2000 cm^{-1} - fingerprint region for bond vibrational modes of polyphenols extracted from *B.*

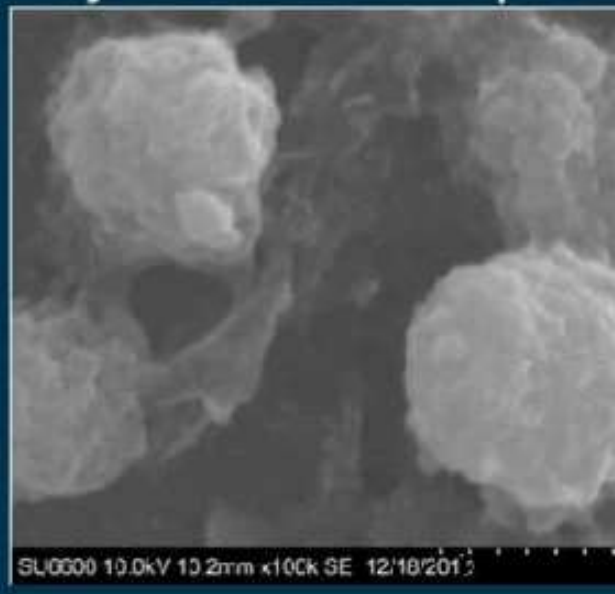
1220 cm^{-1} and 1270 cm^{-1} – bending vibrations of C-O-S and stretching vibrations of Fe=O

SEM Characterization of Iron Nanoparticles

- The shape and size of Fe-NPs were investigated by SEM techniques







- Fe-NPs - well dispersed
  - low aggregation

EDS Characterization of Iron Nanoparticles

- The synthesized nanoparticles were characterized by EDS for the chemical identification of elements and their concentration.

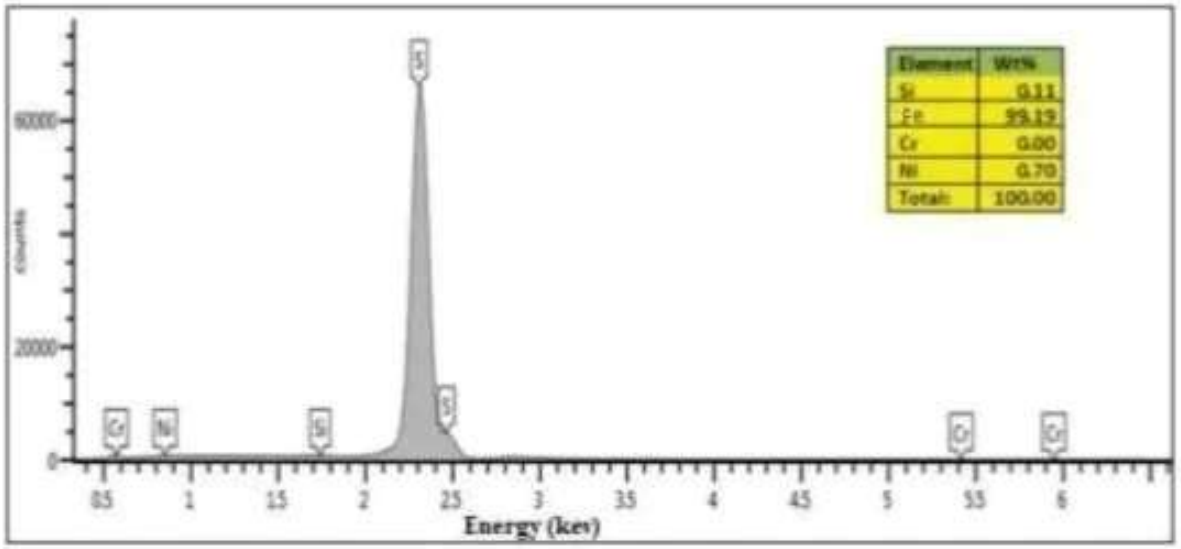


Figure 3: EDS spectrum of the Iron nanoparticles.

XRD Characterization of Iron Nanoparticles

- XRD technique was used to determine the structure (Spatial arrangement of atoms) and the size of the Fe-NPs.

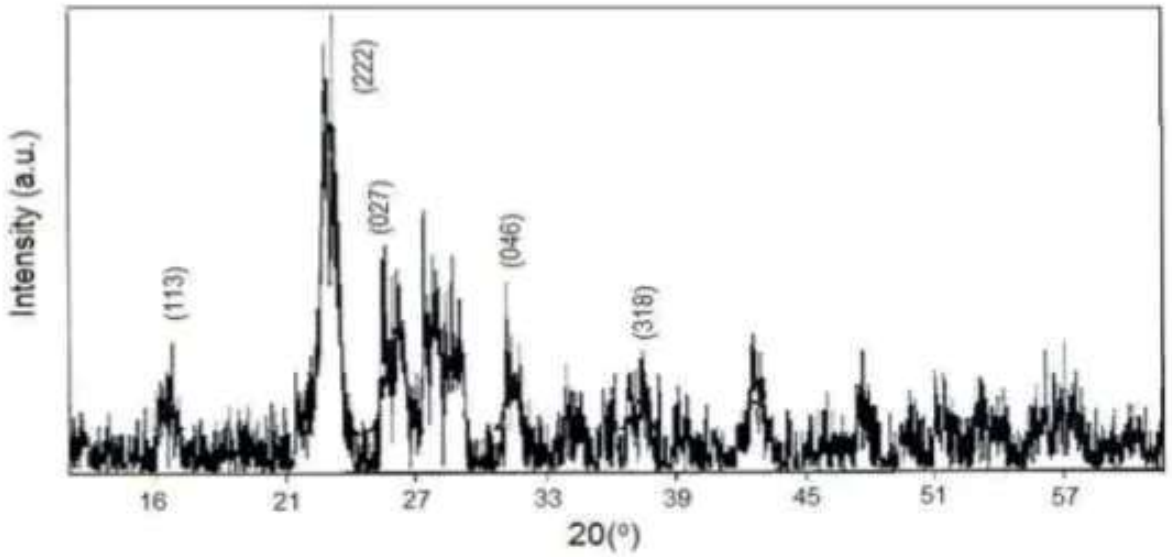
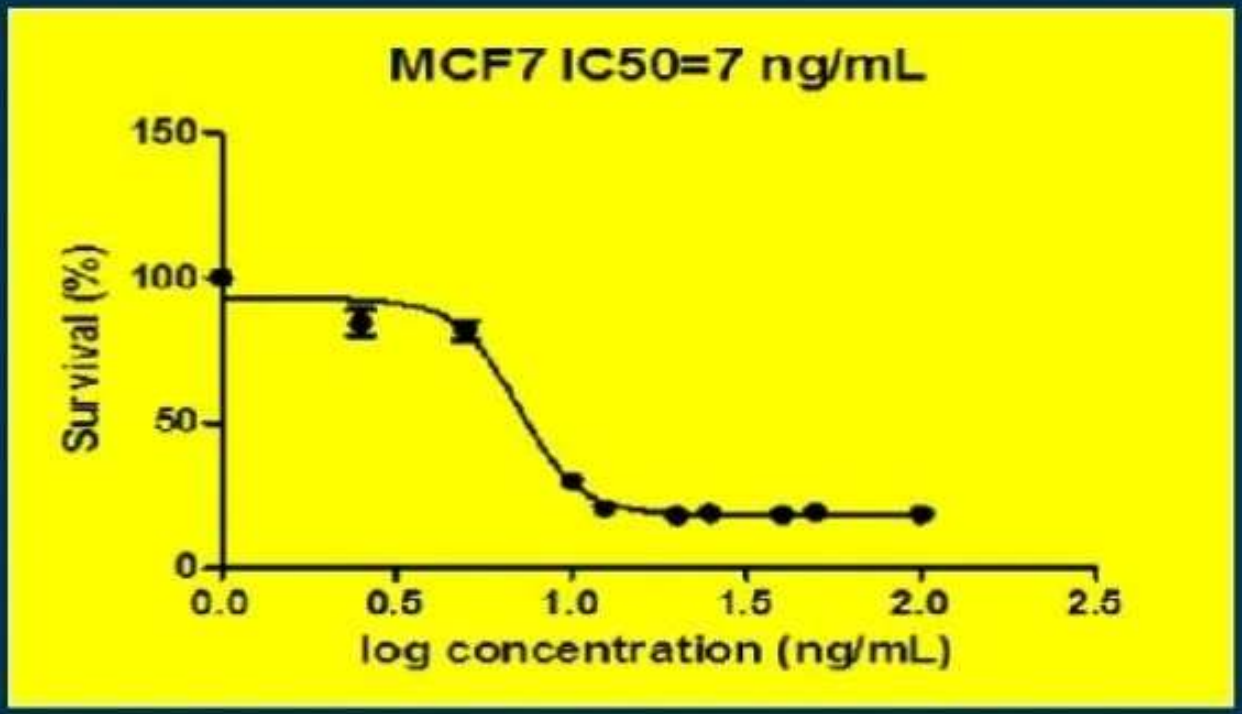


Figure 4: XRD pattern of the Iron nanoparticles.

Iron oxide Fe NPs as induced in vitro cytotoxicity effects

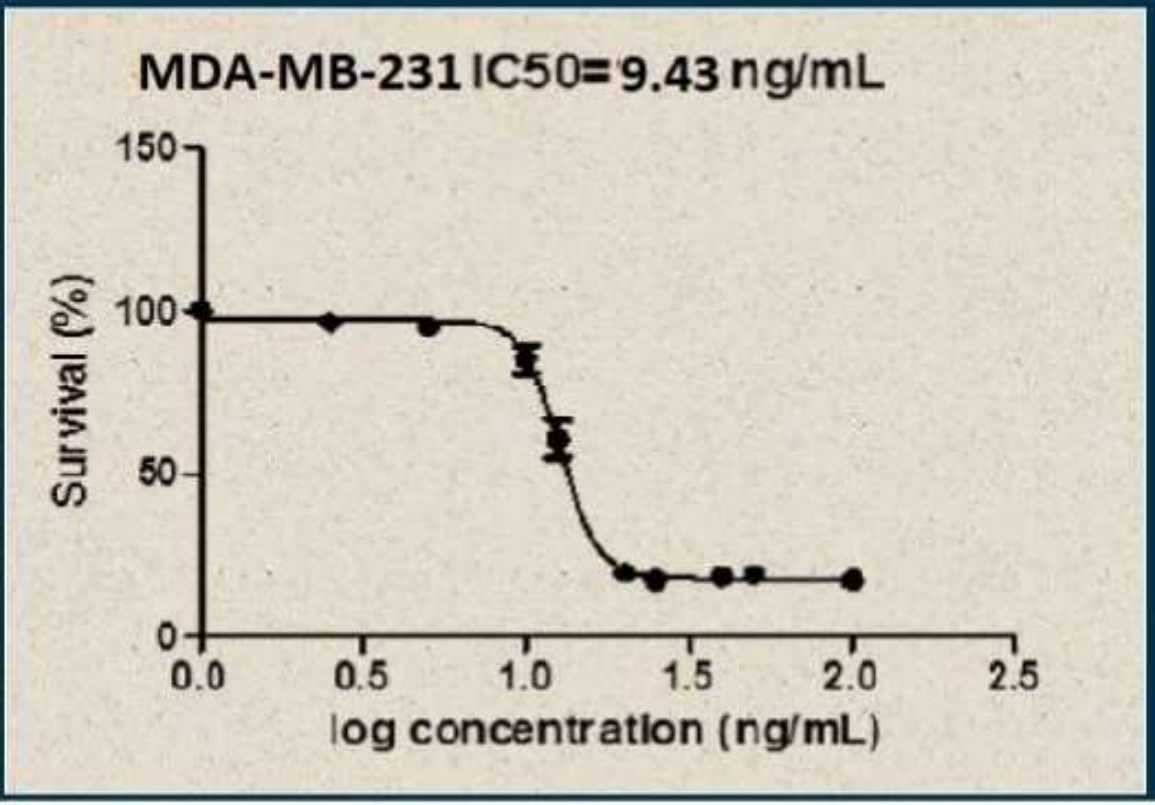
IC50 measurement cell lines for nanogram / ml concentrations

Cell line	Phytoconstituents based Fe- NPs (IC_{50})	Flavonoids & Polyphenols (IC_{50})
MDA-MB-231	9.43 ng/mL	> 320ng/mL
MCF-7	07 ng/mL	>200ng/mL



Cytotoxicity effect of Fe- NPs as nanomedicine induced growth inhibition in breast cancer cells MCF-7

50000, 25000, 1000, 500, 250, 100, 50 ng/ml, concentrations and incubated at 37 °C after h incubation.



50000, 25000, 1000, 500, 250, 100, 50 ng/ml concentrations used for treatment after 72 h in MTT assay.

It was found that ZnO QD NPs as nanofluid demonstrated stronger cytotoxicity against breast cancer cell lines MCF7 than colon HT-29 cancer cells

Cell survival rate (%) of Cervical cancer cell line, after 72 hours of

Conclusion

- FeNPs play an important role in improving liver, kidney and the heart functions of resulted insignificantly increase activity against tumour and shows high antiproliferation activity against (MCF-7, HepG2, HCT116 and PC3) cell lines, and significantly increase with FeNPs reduced most of the hematological parameters in the treated group compared to the positive control group.

Nanotechnology Potential in Oncology

Nanoparticles have great potential due to their exclusive properties like small size, surface-to-volume ratio, tunable surface chemistry, and the ability to encapsulate v drugs, the nano-sized carriers provide longer circulation time; easy penetration into cellular membranes; efficient site-specific targeting.

1. Diagnosis
2. Medical Imaging
3. Drug delivery
4. Therapy

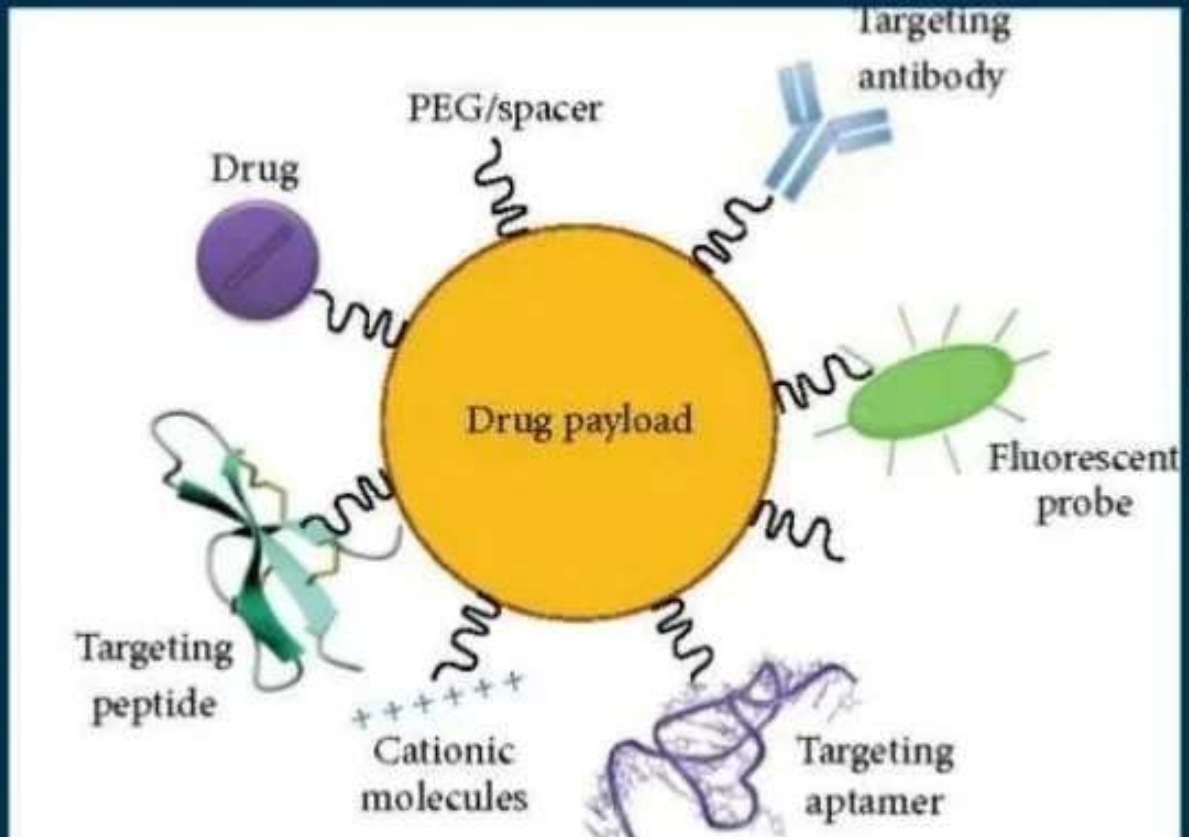
Diagnosis and Medical Imaging

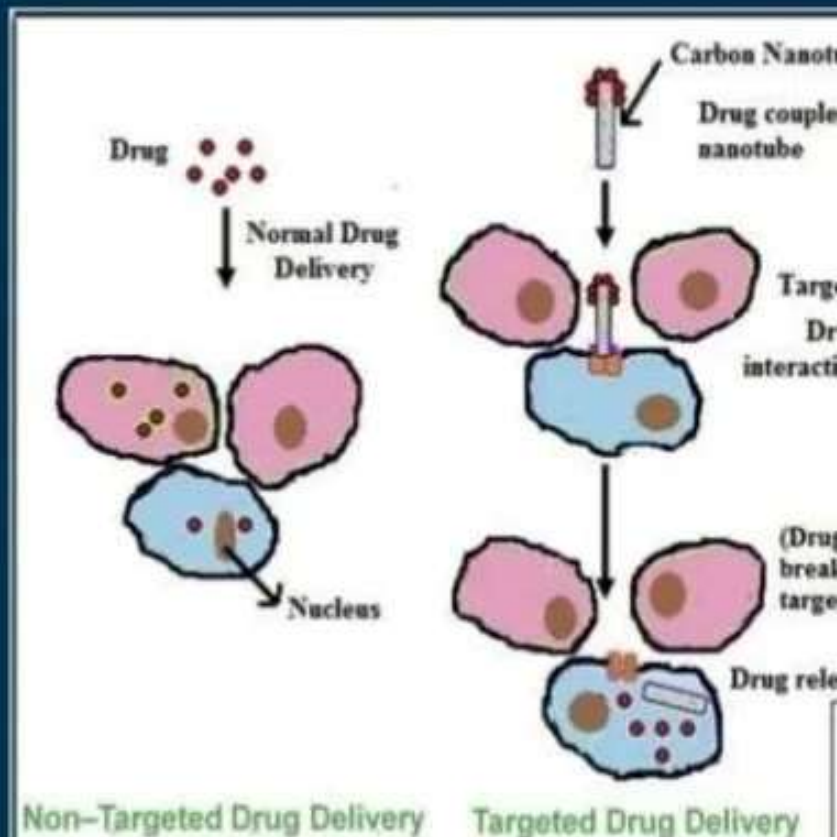
- Tiny tumors in mice can be detected with the injection of nanoprobes which are light-emitting nanoparticles that emit short-wave infrared light as they travel through the bloodstream.

Drug Delivery

- Nanoparticles (NPs) are the new identified tools by which we can deliver c into tumor cells with minimum drug leakage into normal cells.
- Conjugation of NPs with ligands of cancer specific tumor biomarkers is a p therapeutic approach to treat cancer diseases with the high efficacy.
- It has been shown that conjugation of nanocarriers with molecules such as antibodies and their variable fragments, peptides, vitamins, and carbohydr can lead to effective targeted drug delivery to cancer cells and thereby can attenuation

Drug Delivery





Therapy

- **Nanoshells kill tumor cells selectively.**

Nanoshells can be designed to absorb light of different frequencies generating heat (hyperthermia). Once the cancer cells take up the nanoshel active targeting), scientists apply near-infrared light that is absorbed by the nanoshells, creating an intense heat inside the tumor that selectively kills tu cells without disturbing neighboring healthy cells.

Therapy

- **Nano X-ray Therapy**

Nanoparticles are injected into tumour site directly. Nanocryst
accumulate there and wait for activation. Standard X-rays activate the
particles in the patients tumour. The nanocrystals are optimized to abs
more X-rays and produce many more free radicals from water, damagi
the tumour cells more severly than the surrounding healthy tissue.

Reference

- Faten Z, Mustafa H, Muayad ALD (2018) Synthesis of Nano Su
  Particles and their Antitumor Activity J Microb Biochem Technol
  56-68. DOI: 10.4172/1948-5948.1000397

Thank You