

NANO CHEMISTRY & CHEMICAL MICROSCOPY

1. BASICS OF NANOCHEMISTRY

Definition: Study of materials with dimensions between 1–100 nm.

Nanomaterials: Unique optical, electrical, magnetic, and mechanical properties due to high surface-to-volume ratio. Quantum effects become significant at nanoscale → changes in color, conductivity, and reactivity.

2. NANOPARTICLES & NANOMATERIALS

Types of Nanoparticles:

Metal (Au, Ag, Pt) – Catalysis, biosensing.

Metal oxide (TiO_2 , ZnO , Fe_2O_3) – Sunscreens, photocatalysis.

Semiconductor (CdS , ZnS) – Quantum dots, LEDs.

Polymeric – Drug delivery.

Carbon-based – Nanotubes, nanorods, nanofibres, graphene.

Preparation Methods:

Top-down: Breaking bulk material (milling, lithography).

Bottom-up: Building from atoms/molecules (sol–gel, CVD, precipitation).

Properties:

Large surface area, quantum confinement, catalytic enhancement, tunable conductivity/magnetism.

Uses:

Catalysis, sensors, drug delivery, coatings, batteries, solar cells, imaging.

3. CARBON NANOMATERIALS

Carbon Nanotubes (CNTs): Cylindrical graphene sheets (single or multi-walled).

→ Properties: High strength, conductivity, flexibility.

→ Uses: Conductive composites, nanoelectronics, drug delivery.

Nanorods: Rod-like, used in displays, optoelectronics.

Nanofibres: Thread-like, used in filtration, tissue engineering.

4. POROUS SOLIDS & OTHER NANOSTRUCTURES

Nanowires: 1D materials with high electron mobility.

Nanomachines: Molecular devices performing mechanical functions.

Quantum Dots: Semiconductor nanoparticles with size-dependent luminescence (used in LEDs, imaging).

5. METHODS OF NANOMATERIAL SYNTHESIS

Sol-gel method: Hydrolysis & condensation.

CVD (Chemical Vapor Deposition): Vapor phase deposition.

Co-precipitation: Solid formation from solution.

Hydrothermal/Solvothermal: High temp/pressure synthesis.

Electrochemical methods: Controlled deposition.

Green synthesis: Plant/microbial reduction.

CHEMICAL MICROSCOPY

1. OPTICAL MICROSCOPE

Parts: Light source → condenser → specimen → objective → eyepiece → eye.

Magnification = Objective × Eyepiece.

Applications: Crystals, fibers, biological tissues.

2. ELECTRON MICROSCOPY

Principle: Uses electron beam → higher resolution.

Types:

- SEM: Scans surface → 3D image.
- TEM: Transmits electrons → internal structure.
- EDS: Elemental analysis (attached to SEM/TEM).
- Electron Probe Analyzer: Quantitative mapping.
- Ion Microscopy: Uses focused ion beam for imaging.

Sample Preparation: Dehydration, coating (Au/Pd), ultra-thin slicing.

Applications: Morphology, nanostructure, defects, particle size.

3. FLUORESCENCE MICROSCOPY

- Uses fluorescent dyes → emit higher wavelength light.
- Confocal: Laser scanning, 3D imaging.
- Phase Contrast: Enhances contrast in transparent samples.

SPM Family:

- AFM: Surface topography via cantilever tip.
- STM: Measures tunneling current, atomic resolution.
- MFM: Maps magnetic domains.
- EFM: Maps surface charges.

4. XPS / ESCA (X-ray Photoelectron Spectroscopy)

Principle: X-rays eject core electrons → kinetic energy gives binding energy.

Instrumentation: X-ray source, analyzer, detector, vacuum.

Applications: Elemental composition, oxidation state, bonding, surface (1–10 nm).

5. AUGER ELECTRON SPECTROSCOPY (AES)

Principle: Emission of Auger electrons after core ionization (element-specific).

Instrumentation: Electron gun, energy analyzer, detector.

Applications: Surface analysis, thin-film study, depth profiling.